Sea Frontiers

Bulletin of the INTERNATIONAL OCEANOGRAPHIC FOUNDATION

Volume 5, No. 3

NEW SPECIES OF SEALIFE? *No, just some blue mussels that formed an attachment with a blue crab in the congenial waters of Chesapeake Bay. The alliance poses a question for marine biologists: Since blue crabs do not bed down until early December in the Chesapeake, did full grown mussels transfer to the crab, or did they "set" to the crab and grow to this size in the relatively short period of two months? (Photo from Claude Rogers)*

FRONT COVER. "THAR SHE BLOWS!" *A harpoon gunner takes careful aim in the pitching seas of the Arctic Ocean. Harpoon guns greatly simplified Norway's small whale hunting industry. While some whale meat is sold for human consumption much of it finds its way, in Norway, into animal food, particularly for fox farms. (Gustav Hansson from* Black Star)

BACK COVER. THROUGH THE GENEROSITY *of a member of the Foundation, The Marine Laboratory of the University of Miami has added this handsome staysail schooner to its fleet. The 65-foot overall* Barlovento, *a gift of Pierre S. du Pont III, of Wilmington, Delaware, will be engaged in submarine geology and acoustics work, where a "silent ship" is needed. She will also be used for training oceanographers in seamanship. (Charles E. Lane)*

SEA FRONTIERS

Bulletin of the INTERNATIONAL OCEANOGRAPHIC FOUNDATION

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Published Quarterly.

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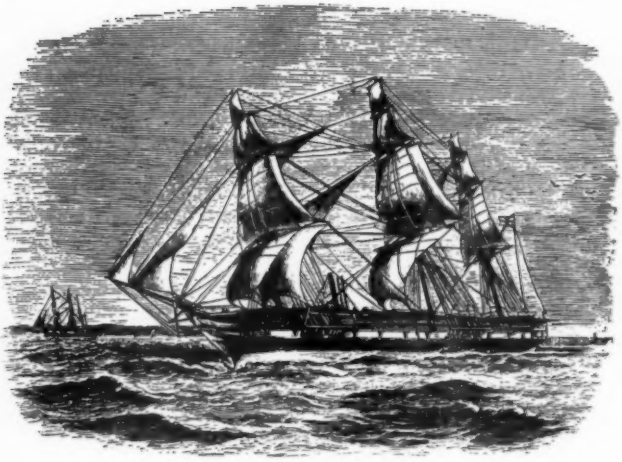

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Toward A Broader View

WHILE THE STUDY of the sea is by no means a new venture, dating back as it does to the dawn of civilization, it has never been as thoroughly carried out nor as well coordinated as scientific exploration on land.

Many reasons could be given for this apparent discrimination. Sea studies, particularly those well offshore, are not as easily carried out as those on land. Also, the open sea, which until recently meant salt water "beyond the three mile limit," is politically international. Except for a few nations with heavy maritime interests, the general attitude toward oceanic research has been "let George do it," that is, let some larger and richer country spend time and money to gather basic facts beyond territorial borders.

Like Topsy, "jest grew!"

Still another factor has handicapped oceanography, marine biology,

TED NATIONS, NEW YORK, *scene of first International Oceanographic gress, August 30 to September 12, 9. UN provides an appropriate place such a meeting because the high seas* international *and, in theory, belong ally to all nations for the purposes ommerce and travel, and food and r resources, except where restricted* international *agreements. And, of rse, oceanography is, even more n other sciences, international in its ook. (United Nations photo)*

marine geology, and meteorology—the principal sea sciences. For lack of a better word, call it "coordination." Until the advent of the International Geophysical Year, most studies of high seas currents, ocean bottom contours, dynamics of organic and inorganic substances, weather origins, etc., like Topsy, "jest grew." Projects were conceived and launched without very much international reference, consultation, or projection into the future.

International, and Free

As a result, progress in oceanic research has been retarded by elements both within and beyond the control of scientists and scientific institutions most vitally concerned. Findings of the International Geophysical Year, now coming to light as reports are finished and published, indicate quite clearly that piecemeal study, either by individuals or by nations, is no longer the solution; it simply will not supply the answers to hundreds of highly involved, overall questions still locked in the mysterious depths of the sea—the last great earthbound frontier.

Despite some recent unauthorized and rather highhanded extensions of territorial limits into the sea by a few countries, the vast watery domain that covers nearly three-quarters of the earth remains *international*. That is, in theory it belongs equally to all countries for the purposes of commerce and travel, and food and other resources, except where restricted by *international* agreements. "Freedom of the seas," at first enforced by powerful maritime nations, has long been considered a basic concept of the democracies, whose ships and trade far outnumber those of any other countries.

It is only logical, therefore, as the world's exploding populations turn to sea resources to meet such fundamental needs as food, minerals, and even fresh water, that a broader viewpoint in oceanic matters, and particularly oceanic research, must be taken. This is true not only of those who live in maritime nations, but of those in countries completely landlocked.

Most Ambitious Conclave

By far the most ambitious attempt to bring oceanic experts together, and to survey the whole domain of the sea as it has been revealed to date, will take place at the United Nations Building, in New York City, August 30 to September 12. This first International Oceanographic Congress is expected to attract top-ranking staff members from marine laboratories and other oceanographic institutions, as well as many other observers in related fields, from all over the world.

The Congress, sponsored by such ranking organizations as the American Association for the Advancement

of Science, in collaboration with the International Advisory Committee on the Marine Sciences of UNESCO, and the Special Committee on Oceanic Research of the International Council of Scientific Unions, will offer a long-needed forum and common meeting ground for all sciences concerned with the oceans and the organisms contained in them.

No Mechanical Gimmicks

The general public and those in other branches of science, however, should not expect any new gimmicks, such as deep-sea exploring vehicles, or sea water conversion plants, or mineral extractors. The Congress will be devoted to the fundamentals of the marine sciences, rather than to their applications.

Because so much basic work remains to be explored in this area, the program of the Congress will wisely be centered around five broad symposia on the oceans—the history, the boundaries, the deep sea, dynamics of organic and inorganic substances, and the marine life regime. Morning lectures will be followed by afternoon round-table discussions, seminars, and related papers. Among the lecturers and seminar leaders will be scientists from most of the leading marine laboratories of the United States, as well as those from Great Britain, Denmark, U.S.S.R., Canada,

UNTIL RECENTLY, *oceanic research was conducted by a comparatively few nations, chiefly those with heavy maritime interests. Now many countries are participating, including Canada, whose new* A. T. Cameron *is shown sailing down the St. Lawrence. Built for the Fisheries Research Board of Canada, the* A. T. Cameron *has five modern laboratories capable of carrying out oceanographic, hydrographic and survey work, and quarters for nine scientists and technicians. The ship also contains an 1,800 cubic-foot fish hold. (Canadian Department of Fisheries)*

Germany, Belgium, Sweden and Holland.

I. O. F. Represented

The International Oceanographic Foundation will be represented at the meeting by several of its officers and members. In addition, the Foundation, through the generosity of one of its Corporate Associates, is contributing towards the expenses of delegates from Scandinavian countries attending the Congress.

Although it is not on the agenda, the role of marine sciences in the future will inevitably be discussed, as well as some of the challenging oceanic projects, now in the blueprint stage, and theoretical problems the solutions of which still lie far ahead. All of which is very stimulating and important. Everyone in the small but growing group of those engaged in oceanic research wishes the Congress every success in its pioneering effort to bring together, for the first time, representatives of all the marine sciences. Oceanography, too, stands on the threshhold of the new golden age of science. Its needs and its wonders are no less compelling than such kindred enterprises as modern medicine, nuclear physics, and the exploration of outer space.

Visitors To The Congress From Scandinavia

Our Scandinavian readers will be interested to know that the following scientists, some of whom are members of the Foundation, will be attending the International Oceanographic Congress at the United Nations building, New York:

Anton Fr. Bruun, Denmark; B. Kullenberg, Sweden; Hakon Mosby, Norway; Trygve Braarud, Institutt for Marin Biologi, Oslo-Blindern, Norway; K. Gosta Eriksson, Uppsala University, Uppsala, Sweden; Stig Fonselius, University of Stockholm, Stockholm, Sweden; F. Koroleff, Merentutkimuslaitos, Helsinki, Finland; Gunnar Thorson, Marine Biological Laboratory, Helsingor, Denmark; P. Welander, University of Stockholm, Sweden; Torben Wolff, Universitets Zoologiske Museum, Copenhagen, Denmark; Lars Gunnar Sillen, Royal Institute of Technology, Stockholm, Sweden; Kurt Fredriksson, Sveriges Geologiske Undersokning, Stockholm, Sweden, and Ottos Mellis, Mineralogiska Institutet, Stockholm, Sweden.

SHAMELESSLY MIXING SCIENCE *with phantasy, Pierre Denys de Montfort, who worked for the Museum of Natural History in Paris, invented a* Poulpe colossal *or giant squid, in the early nineteenth century. He said it nearly dragged a ship to the bottom but the crew saved themselves by chopping off its immense arms. An artist depicts "the harrowing incident." (From an old print)*

Hunting Sea Monsters

By GILBERT L. VOSS
The Marine Laboratory, University of Miami

THE TELEPHONE RANG. "This is the Marine Operator," it said. "I have a call from the vessel *Combat*."

A moment later came the excited voice of Harvey R. Bullis, Jr., in charge of the Gear Development and Exploratory Fishery office of the Fish and Wildlife Service at Pascagoula, Mississippi.

"We have a giant squid that we just pulled on board. It is still alive and moving, but is dying. We picked it up a few minutes ago on the surface, where it was being attacked by sharks. Do you want it?"

How to Handle Giant Squid?

Of course we wanted it, but meanwhile what does one do with a whole giant squid? How would they get it to us? Further conversation revealed that they were working a station northeast

of the Bahama Islands and were several days from port. Could they measure and photograph it? Not enough room on deck in the middle of their gear. How big was he? Oh, about half a ton! How long? Estimates varied from 30 to 50 feet.

It was finally decided to keep it in the hold, well packed in ice. The *Combat* was coming south to Miami, shooting her nets as she came.

Ten days later the vessel arrived, with the museum crew of the Marine Laboratory, University of Miami, waiting on the dock. At Harvey's orders the hatch covers were removed, the ice shovelled aside and slowly the great carcass was revealed, still in the cargo net. To the squeal of the winch, the squid was hoisted into a waiting truck and rushed to the Laboratory, where a special tank of formalin had been prepared for it.

Total Length: 47 Feet!

As with most recorded *Architeuthis*, the body and arms were slightly mutilated, but the specimen was estimated to have been about 47 feet in length from the tip of the body to the end of the tentacles! A real sea monster, but not the biggest on record, for they are known to reach a length of about 60 feet.

Then the newspapers descended, including the Associated Press, and

THE AUTHOR EXAMINES *the giant squid captured by the ship* Combat, *while working a station for the Fish and Wildlife Service northeast of the Bahama Islands. Slightly mutilated, the specimen was estimated to have been 47 feet in length from the tip of the body to the end of the tentacles. It has been preserved in the Museum of The Marine Laboratory, University of Miami. (Lowell P. Thomas)*

the story was published throughout the United States. Fellow scientists wrote requesting various parts. One wanted the eyes, because they are the largest invertebrate eyes known. Another wanted the great paired dorsal nerve axons. If those from the comparatively small squid from the Peru Current are the largest nerve fibers known, how exciting it would be to study those of the giant squid. But, we pointed out, these fibers are missing from *Architeuthis*. As the letters came in, however, it seemed that the squid might be scattered far and wide before we had an opportunity to examine it ourselves.

Rare Specimens

Why all the excitement over the capture of a giant squid? These great creatures, the largest living invertebrates, are undoubtedly common in the depths of the sea, but few specimens have come into the hands of scientists, and little is known about their biology, ecology and structure. Nearly all specimens have been given scientific names, many of them duplications.

The Marine Laboratory has three specimens. Some years ago a charter boat brought in the fragments of one found drifting on the surface off Fowey Rock Light, Florida. It was badly mangled. A couple of years later an 18-foot specimen was found drifting on the surface of the Gulf of Mexico. It was turned over to the fisheries research vessel *Oregon*, which was working nearby, again in charge of Harvey Bullis. Termed *Architeuthis physeteris*, it was originally described by Joubin from a specimen

HOW A MAN COMPARES *in size wi giant squid, one of the largest cre of the sea. It has been known to gr an overall length of 75 feet. Not size of the squid's huge eye—almo big as the man's head. (Marine L ratory, University of Miami)*

vomited up by a sperm whale, harpooned by the Prince of Monaco, grandfather of the present Prince Ranier, and a noted oceanographer and marine biologist.

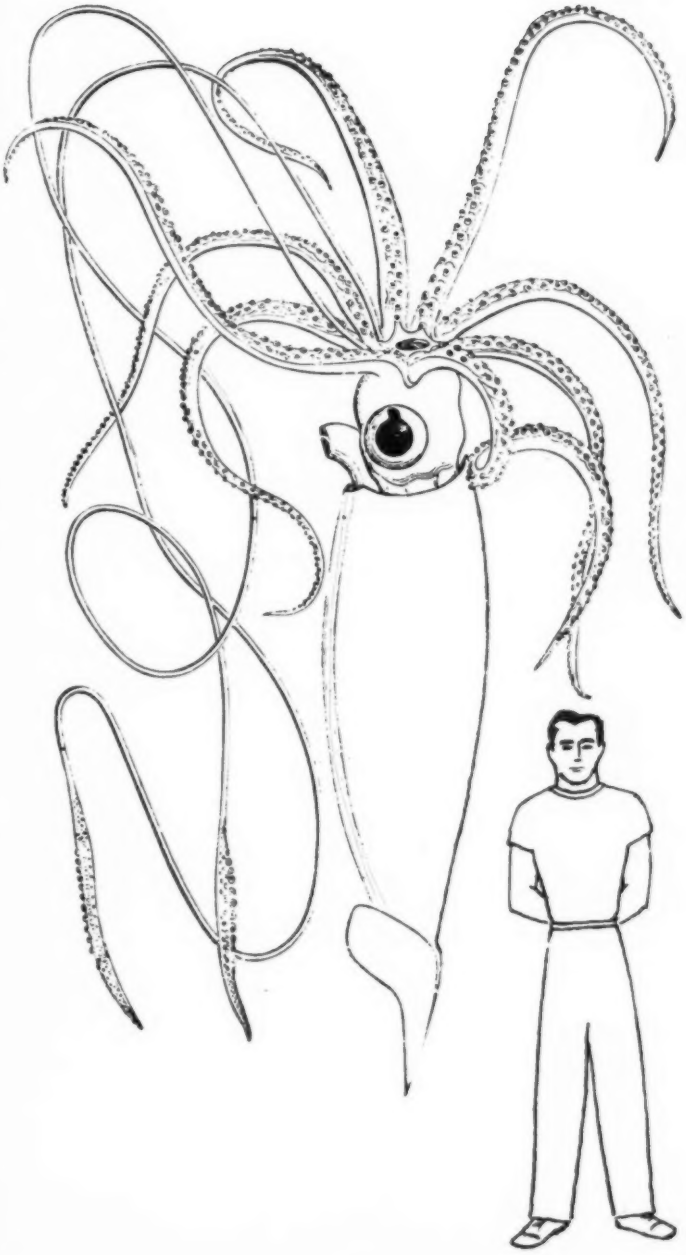
The Terrible Kraken

The giant squid has been known to Europeans for centuries, and elaborately embroidered in fantastic folklore. Olaus Magnus, the last archbishop of the Swedish Roman Catholic Church, first wrote about it extensively in 1555, in his work on the history of the northern nations. He used the old Norwegian name "Kraken." It was described as resembling a great tree torn out by the roots, and capable of inflicting great damage.

Case of the Disappearing Altar

Another churchman, Pontoppidan, a bishop in the Protestant Church, also described the size and ferocity of "kraken" in his history of Norway, published about 200 years after Magnus. He ended by suggesting that despite its great size it resembled the octopus and squid known by the fishermen, and wrote that it undoubtedly belonged to that group of animals, which it does.

A third ecclesiastic, the Bishop of Nidros, is incorporated in a fantastic yarn. He is supposed to have mistaken a kraken for a great rock and, having



AN ARTIST'S IMPRESSION *of an actual encounter between the French corvette* Alecton *and a giant squid off the Canary Islands, November 30, 1861. When the crew attempted to bring it aboard, however, the rope coiled round its tail cut through the flesh, and the mutilated animal escaped. (From an early print)*

built an altar on it, offered up a Mass. The pious squid remained still until the good bishop returned to the shore, whereupon it sank, altar and all, beneath the waves.

Such reports must have raised serious doubts in the mind of the great Swedish naturalist, Linnaeus, for although in the first edition of his *Systema Naturae* he listed the kraken under the name of *Sepia microcosmos*, he deleted it from the 10th and authoritative edition.

But no one did as much to discredit the serious observations of Magnus and Pontoppidan as did Denys de Montfort, a French systematist who around the beginning of the 19th century wrote a weird History of the Mollusks in which he records how the kraken attacked sailing ships, and indeed how a school of them sank ten men-of-war in a single night!

Scientists Accept the Giant!

However, there were a few scientists who, sorting truth from the fictitious, believed in the existence of giant squids. Among these was Japetus Steenstrup from the University of Copenhagen, who gathered together all of the existing data about sightings, strandings and other occurrences and even examined fragments preserved in European museums. Ten years later, in 1857, on the basis of parts that he had seen, he finally gave scientific names to two species, *Architeuthis monachus* and *A. dux*. Admittedly they were based only on jaws and such, but Steenstrup was convinced of their authenticity.

Then, in 1861, occurred one of the strangest battles in the history of marine science. The steam dispatch boat *Alecton*, under the command of Lt. Bouyer, while between Madeira and Teneriffe encountered a giant squid lying on the surface. Lt. Bouyer, realizing the importance to science of securing the specimen, and in spite of a heavy swell, succeeded in maneuvering the *Alecton* near enough to get a running noose around it. But the squid thrashed so that the noose cut it in two, and only a section weighing about 44 pounds was recovered.

The entire animal was said to be

about 15 to 18 feet long in the body, with eight arms about 5 to 6 feet in length. The entire weight of the squid was estimated at about 4,400 pounds. The species was provisionally named *Architeuthis bouyeri.*

Beak Like "a Six-Gallon Keg!"

The scene now shifts to Newfoundland. On February 26, 1873 two fishermen were out in a small punt (or dory) in Conception Bay, off Portugal Cove, when they saw what they took to be some wreckage on the surface. One of the men struck it with a gaff, when immediately it came to life, reared a parrot-like beak which they described as "as big as a six gallon keg," and struck the bottom of the boat violently, after which it twined two arms or tentacles about the craft. Both tentacles were quickly cut off with an axe, whereupon the squid moved away, shooting out great quantities of black ink or sepia. They estimated the total length of the animal at about 60 feet.

Pliant as Leather

Excitedly the fishermen rowed ashore to tell their tale and show the arm which they had cut off. It measured, even with some of it missing, 19 feet. Cartilaginous, the arm was as tough and pliant as leather. Fortunately, the account came to the attention of the Rev. M. Harvey, an ardent naturalist, who gathered all the information and saved the tentacle in a brine solution.

Many Newfoundland Finds

Science owes a further debt to the Reverend Harvey, for in the next ten years Newfoundland, probably due to a shift in bottom currents, saw the capture of nearly two dozen of these great creatures of the deep, and Harvey spent much of his time collecting them. An intelligent man, he soon realized that a trained scientist was needed, and asked Dr. Addison E. Verrill of Yale, America's great early marine biologist and a specialist in mollusks, to help him.

With Verrill on the scene, a series of detailed scientific observations were published, culminating in his monographic report published in 1879 on *The Gigantic Squids (Architeuthis) and Their Allies.* One of the two species he named in honor of his friend, *Architeuthis harveyi,* the other *A. princeps.*

Publication of Verrill's papers satisfied most scientists of the existence of the giant squid. Specimens are preserved in museums, but not many, and few are in really good condition. Apparently, as with the Florida specimens, they seldom are recovered except when suffering from illness, harmed by sharks, or disgorged by sperm whales. Despite our present knowledge of these animals, current popular works are filled, even as in the days of Montfort, with exaggerated stories of their strength and ferocity.

Apparently, any squid reaching a length of over 6 feet is called a giant. Into this category fall exceptionally large specimens of the flying squid, *Ommastrephes bartrami* and *O. pteropus,* the giant squid of Chile and Peru, *Dosidicus gigas,* and even that odd one, the scaled squid, *Thysano-*

DR. FRANCIS O. SCHMITT, *of the Massachusetts Institute of Technology, lands a large squid in Pacific waters off Chile, during an expedition to determine the feasibility of using such squid as a source of material for research upon nerves. (M.I.T. photo)*

teuthis rhombus of which there is a specimen in the Marine Laboratory Museum of the University of Miami weighing 35 pounds. It was taken from the stomach of a blue marlin.

To the specialist, however, the true giant squids belong only to the genus *Architeuthis*. They have been taken in nearly every major area of the oceans, from Australia and New Zealand to Japan; also from the South Atlantic, Florida, Newfoundland, Europe, etc. The largest one actually measured by a scientist was 57 feet in overall length. The tentacles reached 49 feet, 3 inches, but the body was only 5 feet and 7 inches long. This particular specimen had such long tentacles, in fact, that it was named *Architeuthis longimanus*.

Most of the giant squids captured have been about 40 to 50 feet in

length with a weight between 500 to 1,000 pounds. One of 60 feet could easily weigh a ton. In these the body is proportiontely much larger in relation to the tentacles.

Huge But Flabby

Oddly enough, despite all reports of the strength, agility and speed of the giant squids, they are not heavily or strongly muscled, as are their smaller cousins, *Dosidicus gigas,* from the Humboldt Current off Peru. Instead, their bodies have a soft, flabby consistency which is characteristic of squids that live below 100 fathoms in the open sea. Remember, in the battle by the *Alecton,* their rope cut clear through the body of the squid? The arms and tentacles also are quite flabby and easily torn loose from the body.

Examination of the Florida specimens show several features that may give clues to their habits. The parrot-like beaks are large and powerful, but within the mouth the rasping organ or radula is very small and degenerate. In other squids this is large and well developed and is used for ramming chunks of food down the gullet.

Food a Mystery

We still do not know what the giant squid eats, but it seems likely that it feeds on small or soft objects which do not need to be aided in their passage down the throat. Also the horny rings of the suckers are weakly toothed, not heavily taloned as in the large predatory squids. Nor are there curved hooks on the tentacular clubs, such as

GIANT SQUID OF CHILE *are generally shorter than their Atlantic cousins. Including their octopus-like tentacles, squid found off the west coast of South America run only about 8 feet, although a few are longer. (M.I.T. photo)*

are found in most of the deep water species.

In the fast swimmers, the funnel, which is the squid's jet, is powerful, with thick muscular walls and well developed accessory organs such as mantle-locking cartilages, funnel valve and so on. In the giant squids however, these organs are very poorly developed; the funnel is flabby, the valve is weak and the locking cartilages are mere shallow grooves and ridges.

Small Fins Indicate Inactive Life

Even the fins are but flimsy narrow bordering flaps, of little or no use as a means of propulsion. Most important of all, the great paired dorsal nerve axons, which control the movements of the body wall or mantle, are missing, as pointed out earlier. What do all of these things mean?

The late British cephalopod spe-

THE GIANT NERVE *of squid taken off the west coast of South America is as thick as a pencil, and easily removed. From its fibers the axoplasm is extracted and shipped north by air for analysis. Scientists at the Massachusetts Institute of Technology recently discovered, in these fibers, five new peptides which they hope will prove useful as antibiotics. (M.I.T. photo)*

cialist, G. C. Robson, in a paper dealing with a new species, *Architeuthis clarkei,* wrote: "I am inclined on the whole to think that *Architeuthis* is rather a sluggish animal, living near the upper stretches of the continental slope in water between 100-200 fathoms, or deeper where the surface temperatures are high. The structure of the suckers suggests that it does not deal with large prey. The remarkably small size of the fins suggests an inactive life, so that it may keep near the bottom and feed on sedentary invertebrates and carrion."

Robson accumulated all available data on the occurrences of these animals, and, despite the fact that they have been found mostly in cold northern waters, he concluded that their area of greatest concentration in the Atlantic probably lay along the coast of the southeastern United States. He further thought that the reason for the numerous strandings in northern waters was that the squids were brought into cold waters by unfavorable currents and there sickened and came to the surface or were washed ashore.

Scammon, chronicler of the whaling industry of the Pacific, states that the remains of giant squids were common in the Central Pacific and that these always indicated the presence of sperm whales which feed upon them. That sperm whales feed almost exclusively upon squids and often upon giant squids has long been known. According to Akimushkin, who investigated the stomach contents of numerous whales in the Siberian region, sperm whales there do not feed upon *Architeuthis,* but this also is an area of cold water and probably outside of the squid's normal range. However, in the Azores, Clarke took a 35 foot squid from the stomach of a 47 foot sperm whale.

How Whale Snags Squid

How do sperm whales catch these slippery giants? This whale possesses a long narrow bony lower jaw, which can be opened to form a 90° angle with the mouth. Evidently the sperm whale swims through the dark waters of the depths with its great jaw down and snaps it shut when it comes in contact with a squid.

Frank W. Lane in his exciting chapter on the Kraken in *The Kingdom of the Octopus* quotes an affidavit of Captain Drever of the barque *Pauline* that they had seen in their voyage to Zanzibar three whales, one of which was locked in the grip of what appeared to be a sea serpent. As they watched the serpent whirled its victim around and around for about fifteen minutes and then suddenly dragged the whale to the bottom, head first.

Whales Scarred by Huge Sucker

From our knowledge of *Architeuthis* it is certain that it would put up a violent struggle when seized in the jaws of the sperm whale. But it seems hardly possible that this flabby creature could ever perform the feats credited to it.

Sperm whales are known to feed about on the bottom, dredging up food with the long lower jaw, and this is the lair of the giant octopus. One with an arm spread of 30 feet is reported by Dall and sperm whales have

HOLLYWOOD'S VERSION *of a giant squid, used in Walt Disney's film adaptation of Jules Verne's* Twenty Thousand Leagues Under the Sea, *weighed two tons and required twenty-four men to operate it with hydraulics, compressed air, electronics and remote controls. It is even equipped with giant light organs, never found in* Architeuthis *but common in deep sea squid. (Copyright Walt Disney Productions)*

CLAWS LIKE A CAT *describes the armed suckers on the tips of the tentacles of the squid* Galiteuthis. *Like a cat's claws in some species, they can be sheathed or unsheathed at will. In some squids these claws are equal in size to those of the Bengal tiger! Magnification here is about sixteen times normal size. (Carl Chun 1910)*

been taken at whaling stations in the southern ocean with sucker scars the size of dinner plates on their hides. A squid large enough to leave such scars would have to be well over a hundred feet long, but a big octopus would have such suckers.

But there is another possibility. Most records of such struggles between titans are from the Indian and Pacific Oceans and it is possible, in fact probable, that there exists in the depth of the seas gigantic cephalopods, rulers of their domain, of quite a different nature from *Architeuthis*. Possible near relatives would be the smaller giant squids of the Humboldt Current, which attain a length of 8-12 feet and 350 pounds. Their bullet-shaped bodies are heavy and strong, with powerful jet funnels and large fins. Their arms and tentacles are massive and strong and with their beaks they can bite oars and boat hooks in two and eat giant tunas to the bone in minutes.

If one of these ommastrephid squids could grow to a length of 50 to 60 feet, they in turn could prey upon and search out the sperm whale. They would be the most powerful fighting machines the marine world has ever produced, and there is no reason to believe they cannot exist.

Arms With Hooked Claws

Last year in London, Dr. Anna Bidder of Cambridge worked on a squid that could qualify in the most lurid deep-sea drama. While the body was small and weak, the head bore enormous jaws and was surrounded by eight heavy muscular arms which bore great hooked claws and two long tentacles. It was a fearsome creature, but of no exceptional size. However, Dr. Bidder has other remains which point to a squid about 24 feet long and they may grow even longer. It is no relation to *Architeuthis* but is fed upon by the sperm whales of the Southern Ocean.

Even the tales of giant squids attacking ships may not all be fanciful with such creatures lurking about. Several stories have come to light but their authenticity cannot be vouched for. Verrill in his account of the giant

squids gives a report of one that attacked a sailing ship off the Lucayes Islands (Bahamas). It pulled two sailors overboard from the deck but not before the chief steersman cut off one of its arms with a hatchet. The arm measured 3.5 meters (11½ feet) and was the thickness of a man.

But even this cannot equal a newspaper account quoted by Lane in *The Kingdom of the Octopus.* In the London *Times* of July 4, 1874 appeared a story which, if true, is one of the oddest sea stories known. The steamer *Strathowen* bound from Colombo for Madras, sighted on a calm sea about an hour before dusk a small schooner, the *Pearl,* A dark object was seen between the steamer and the schooner, lying half submerged on the surface.

Schooner Pulled Under

As observers from the steamer stared in fascinated horror, the dark object moved over to the schooner, crawled half aboard, stretched sinewy arms into the rigging and masts, and pulled the schooner of 150 tons onto her beams ends and then down into the depths to disappear forever. Five survivors were saved by the steamer's crew, one of which, the captain, had fired upon the squid, for such it was, causing it to attack his vessel.

Could all of this have been accomplished by *Architeuthis?* Possibly there lurks beneath the sea even more gigantic squids, creatures large enough to leave sucker marks the size of dinner plates on the skin of sperm whales and which are formidable opponents to these great cetaceans, giving battle to them and sometimes vanquishing them. Like the great sea serpent, proof of their existence will only be had when a specimen is finally brought to land.

For Further Reading:

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On Architeuthis clarkei, *a new species of giant squid, with observations on the genus,* by G. C. Robson. Proc. Zool. Soc. London, 1933: 681-697, 1 pl.

A Giant Squid Swallowed by a Sperm Whale, by R. Clarke. Challenge Soc. Abstr. 3 (8): 31, 1956.

The Open Sea, Its Natural History: The World of Plankton, by Alister C. Hardy. Collins, London. Chapter 14, 1956. Squids, Cuttlefish and Kin.

Precision Clock from Mud Pies

Mud pies sliced from deep sea cores may appear to be far removed from glaciers that crawled over the earth thousands of years ago. But there is a connection.

Oceanographers at The Marine Laboratory, University of Miami, and geologists of the U. S. Geological Survey have succeeded in turning the glacial time clock back well over 100,000 years. Strange as it may seem, this new data, giving the precise dates of glacial events on *land*, is based on the study of sediments taken *far at sea* and two miles below the ocean's surface.

Temperatures in Sediments

Previous work by Dr. Emiliani, reported in Vol. 4, No. 1, of *Sea Frontiers*, showed that the temperatures of ancient seas are more or less permanently recorded in the ancient sediments of today's sea floor in the form of their oxygen isotopes. The ratio of these isotopes varies according to the temperature at which the sediments were formed and so relates them to glacial periods. The newly reported investigations have added to this a more precise way of dating the age of the sediments, based upon the amount of thorium and protoactinium in them. The result is a far more accurate dating than heretofore possible.

More and more, science is turning to the sea to find answers to many of earth's problems. Dr. John Rosholt of the U. S. Geological Survey and Drs. Fritz Koczy, Johannes Geiss and Cesare Emiliani of the University of Miami based their findings upon fine sediments which cover the floor of the Caribbean Sea. By measurements of radioactive thorium and protoactinium in these sediments, it has been possible to place the age of the last interglacial period at almost exactly 100,000 years ago, thus confirming theoretical estimates previously made by Dr. Emiliani. These sediment samples or deep sea cores were taken in the central Caribbean area by the Woods Hole Oceanographic Institution research vessel *Atlantis*, by means of a device which drives a tube into the sea floor. Since sediments accumulate at the rate of about one inch in a 1,000 years, a score sampling tube penetrating beneath the sea floor may easily reach sediments of 100,000 years or more.

How They Were Dated

The radioactive content of the sediments provides a means of dating these samples. Oxygen isotope measurements made from the sample give the temperature of the sea at the time the sediment was deposited, thus linking it to the various glacial and interglacial periods of land, which influence the sea temperatures.

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Meteorology and the Sea

By C. E. N. FRANKCOM

Marine Superintendent, Meteorological Office
British Air Ministry

BECAUSE THE OCEANS OCCUPY three-quarters of the world's surface, it is perhaps not surprising that the study of meteorology (variations of heat, moisture, winds, etc., in the atmosphere) owes its origin first to those who sail on the sea, and later to those who travel over and under its surface.

An American Naval officer, Matthew Fontaine Maury, invalided out of the U.S. Navy and working in the Hydrographic Office ashore, inspired the first international meteorological conference, held in Brussels in 1853.

Cut Costs of Voyages

While at sea, Maury developed an interest in general science. He realized that the shipping industry would derive much practical benefit if it knew more about meteorology and winds, as well as the currents of the ocean. Extracting a multitude of observations from the logbooks of American naval and merchant ships, he compiled a treatise on maritime meteorology and oceanography entitled *Sailing Directions*.

This was accompanied by numerous charts and diagrams of the currents and winds of the world and, as a result of Maury's studies, sailing ships were able to make shorter, more predictable and therefore much more economic passages than hitherto.

Instruments Loaned

At the Brussels conference, representatives of all maritime powers agreed to persuade the masters and officers of merchant ships to make observations, so that charts and other data of a more comprehensive nature than those prepared by Maury could be compiled. A direct result of this conference was the establishment of a Meteorological Office in Great Britain in 1855, and in certain other countries. The first Director of the British office was himself a seaman —Admiral Fitzroy.

Ever since then, meteorological and ocean current observations have regularly been made aboard a large number of ships of various nations. Instruments have been loaned to the ships by the governments concerned. These observations have been recorded in special logbooks and, from the data extracted, "climate-atlases" showing wind, weather, temperature of air and sea, humidity, visibility, etc., have been compiled by such maritime powers as Germany, the Netherlands, the United Kingdom

M THE AIR A WEATHER SHIP *seems a very tiny David, battling the fury a sea Goliath. This striking photoph was taken from an R.A.F. airit during an air-sea rescue exercise, out in the Atlantic. (Copyright* News onicle)

EVEN IN STORMS LIKE THIS *weather ships come to the aid of other vessels. While this photograph was being taken, a disabled seaman moved safely by breeches buoy to the weather ship, despite 30-foot waves and a wind force of 8. (Crown Copyright. O.W.S.* Weather Explorer)

and the United States. Additional atlases show the strength, direction and constancy of ocean currents.

Gale Warnings since 1850s

The spur which goaded governments to take ship observations was an economic one, but interest in meteorology ashore soon developed. During the latter part of the 1850s, a crude form of gale warning and weather forecasting system was developed, out of which has grown a vast international weather service.

Before the introduction of wireless telegraphy aboard ship, in 1901, meteorological observations were merely recorded in logbooks and handed in at the end of a voyage. With radio, the area of immediate information about weather conditions was extended, and it was not long before ships voluntarily sent radio weather messages to shore stations, in addition to recording data in logbooks.

Code for Weather Messages

During World Wars I and II, all meteorological work aboard merchant ships ceased, because of the risk of giving information to the enemy. After World War I, the International Meteorological Organization (founded 1872) evolved a code for radio weather messages from all ships. By 1939, a total of over 1,000 ships of various nations were co-operating in this scheme.

In 1947, following an international conference in Washington, D.C., a universal meteorological code for shipping, aviation and shore purposes was introduced. Arrangements were made to increase the number of voluntary observing ships in the world, and to divide oceanic areas into agreed "spheres of influence," whereby ships would send radio weather messages to appointed stations which, in return, would issue weather bulletins for shipping by radio.

Observing ships now total about 3,000, divided into three catagories: (1) "Selected" ships which make detailed observations; (2) "Supplementary" ships, whose work is somewhat less exacting; and (3) "Auxiliary" ships, which make only very simple observations where shipping is sparse.

"International Shorthand"

Meteorological observations made aboard merchant ships include wind force and direction, barometric pres-

sure, visibility, description of weather (rain, snow, thunder), air temperature and humidity, sea temperature, estimated direction, period and height of waves, and data about cloud formations. Observations are reduced into a "5-figure code" — in effect an "international shorthand," because it is understandable to meteorologists all over the world.

Thus a message from a ship might read:

30500 23306 52924 97038 84348 . . . . the meaning of which would be:-

Tuesday
Latitude 50°N Longitude 23°-15'W
Time 0600 G.M.T.
5/8ths of sky covered with cloud
Wind direction 290°, 24 knots
Visibility 6 miles
Present weather partly cloudy with cloud amount increasing.
Past weather occasional showers
Barometric pressure 984.3 mb.
Air temperature 48°F. . . . .

Any Meteorites or Waterspouts?

In addition to routine observations, it is customary for ships to make note of anything unusual, such as aurorae, meteorites, waterspouts, whales and odd fishes, discolored water, or birds or insects sighted in mid-ocean. Some of these data prove extremely valuable.

Special efforts are made by the various countries to recruit as many ships as possible, particularly those sailing unfrequented waters.

In the Atlantic and North Pacific Oceans, owing to the relatively large amount of aviation traffic, and particularly in the Atlantic, where air traffic is dense and weather conditions sometimes notoriously bad, an international network of Ocean Weather Stations has been established. (See map.)

WEATHER SHIPS MUST BE READY *for any emergency. Here, in a drill, an "injured survivor" is brought on board from one of the ship's small boats. A plane in distress can home on a weather ship by radio aids and, if necessary, ditch alongside. On two occasions planes have done so, and everyone was saved. (Crown Copyright. O.W.S.* Weather Watcher)

Two to Three Ships per Station

At least two weather ships are required to operate an ocean station. In the case of the more distant sta-

WEATHER MESSAGES FLASHED BY RADIO *give warning to both surface and aerial craft of impending storms and other adverse sea conditions. Before the introduction of wireless telegraphy aboard ships in 1901, weather observations were merely filed in a log book and handed in at the end of the voyage. (Crown Copyright. O.W.S.* Weather Explorer)

tions from land, as many as three ships may be needed. At the ocean stations for which the U.S.A. is responsible, Coast Guard cutters are used; the Canadian, French and Netherlands vessels are frigates, whereas the British and Norwegians employ "Flower" class corvettes — the same type ship described by Nicholas Monsarrat in *The Cruel Sea.*

Early Weather Stations

This network of ocean stations in the North Atlantic was established under the auspices of the International Civil Aviation Organization (I.C.A.O.) in 1947, with thirteen stations, later reduced to nine. The Pacific stations are the result of a separate arrangement.

The idea of ocean weather stations is not new. In 1938 the French had a "stationary meteorological ship" the *Carimare,* operating in the North Atlantic, and the Germans used two vessels in connection with their Zeppelin service to South America.

Prime advantage of an ocean weather station is that regular observations of meteorological conditions, both at the surface and in the upper atmosphere, can be made and transmitted by radio from a "fixed" point in the ocean. These observations are not only essential for aviation, but are valuable for general meteorological purposes. Ocean weather ships thus supplement in-

formation provided by merchant ships.

Life Aboard a Weather Ship

What is life like aboard a weather ship? Constant activity is a good answer. Surface observations are made and transmitted by radio to authorities ashore every three hours. At intervals of six hours, upper wind observations are made to a height of 60,000 feet. "Radio Sonde" observations of pressure, temperature and humidity must be carried out to a similar height every twelve hours.

Upper wind observations are made by attaching a metallized target to a large balloon filled with hydrogen, and then tracking the target by radar as it rises through the atmosphere. As winds in the upper atmosphere may have speeds up to 200 knots, the value of such observations for aviation is obvious.

Ready for Any Emergency

In addition to making meteorological observations, all weather ships have radio navigational aids, including a medium frequency beacon, and they also provide aircraft with "fixes" by radar. Radio equipment aboard enables a weather ship to communicate with aircraft on various frequencies, both by radio telephone and radio telegraphy, as well as to keep in constant touch with the shore. In addition, it provides limited air traffic control services, and gives aircraft in flight any weather data requested.

In the event of an "air/sea rescue" call, an aircraft can "home" on a weather ship by radio aids and, if necessary, "ditch" alongside her. The weather ship then would be able instantly to begin rescue work. For this reason, all weather ships have complete air/sea rescue equipment, including power-driven boats, immersion suits, searchlights, and first-aid kits. Crews are expertly trained for such emergencies. Happily the number of incidents of this nature have been rare, but on two occasions planes have ditched alongside a weather ship and everyone was saved.

Even Some Bird Watching

In addition to their routine duties, the weather ships do a certain amount of oceanographical and other special scientific work. Thus aboard the British weather ships, seismic observations have been made by scientists from Cambridge University to obtain

WHAT IS LIFE LIKE ON A WEATHER SHIP? *Constant activity is the best answer. In the balloon shelter, meteorologists prepare a radio sonde balloon for launching. Flasks in background contain hydrogen for inflating the balloon. Radio sonde balloons are sent up twice a day while the weather ship is on station. (Crown Copyright)*

VOLUNTARY WEATHER OBSERVERS on merchant ships also play an important role. Here a ship's officer notes temperature and humidity. Voluntary observing ships now total more than 3,000. They send radio weather messages to appointed stations, which, in return, issue weather bulletins for shipping by radio. (Crown Copyright)

data about the composition of the sea bed. Special experiments have also been carried out with rainfall, radiation, and micro-temperature readings of sea and air: magnetic variations have been observed, and even some bird watching done. It is surprising how many sea and land birds of various species can be seen at an ocean station located three hundred miles from the nearest land.

Normally 24 Days On Station

The British weather ships are based at Greenock, in Scotland, and they normally spend twenty-four days on station; their total time at sea may vary from thirty to thirty-six days, depending upon the location of the station. Sea duty is followed by from eleven to twenty-two days in harbor. Weather ships of other nations carry out similar programs.

The ship's company of a British ocean weather ship totals fifty-three, of whom fourteen are on deck duty, twelve in the engine room, ten radio and radar, seven meteorologists, and ten in food and supplies.

Growing Need for Data

During recent years, the need for accurate and frequent meteorological or weather information for all forms of transport, agriculture, industry, sport, and the public generally has been steadily growing. To provide such a service all meteorological agencies must have a constant flow of up-to-the-minute information about the weather at sea, because most changes in the weather are born at sea.

Meteorology and oceanography figured prominently in the special studies made during the International Geophysical Year. Weather ships, as well as the voluntary observing merchant ships, played their part in providing information from the oceans. Much of this work was routine, but special efforts were made

LAUNCHING A WEATHER BALLOON. *The balloon carries "radio sonde" equipment to send back to the ship observations on pressure, temperature and humidity, and also a metallized target which may be tracked by radar, determining the speed of winds up to 60,000 feet. (Crown Copyright)*

to recruit voluntary observing ships trading in unfrequented waters; to encourage a high accuracy standard in all reports; and to obtain world-wide aurora observations and descriptions. Aboard weather ships the upper air observations attained a greater height than usual and measurements of incoming and outgoing radiation near the sea surface were made.

The ocean weather ships and the voluntary merchant ship observers represent a unique example of an international team working for the benefit of merchant shipping, yachtsmen, scientists, commercial fisheries, and others too numerous to mention. In fact, it is difficult to conceive of anyone or any occupation that does not have some interest in the vagaries of the weather, and more accurate forecasting of them. So, the observations from the weather ships and from merchant ships play their role in the well-being of all of us, afloat or ashore.

Reversing a Salt Cycle

During the Yankee blockade of Southern ports in the Civil War, the State of South Carolina operated a salt-from-the-sea plant on Greenville Sound. Today, at nearby Harbor Island, the U. S. Department of Interior's Office of Saline Water has several pilot plants for turning sea water into fresh, clear, palatable water. During the process, a concentrated brine is produced and, because salt has now become one of the very cheapest commodities, the brine is pumped overboard as waste.

THREE LITTLE LOBSTERS. *As the young lobster matures it changes its appearance considerably. In fact, baby lobsters may vary in size, although of the same age. Unlike fish, lobsters do not have scales or bones by which their age can be determined but by tagging, and other indirect methods, biologists have determined that they first spawn when about five years old. (U. S. Fish and Wildlife Service)*

Salty Knight-In-Armor

By C. P. IDYLL

PERHAPS YOU HAVE WALKED through a large hall in the Metropolitan Museum of Art in New York City, and seen its display of mediaeval armor. How magnificent the knights who wore these gleaming suits, and how graceful they must have been on their horses! But how helpless out of the saddle, sprawling immobile on the ground, their dignity gone, while they waited for their squires to rescue them.

A lobster out of water is not unlike an unhorsed knight. His "steed," to strain an analogy, is the sea. Losing its salty buoyancy, the lobster flounders helplessly on land, borne down by his dark green armor.

One of the most familiar and famous of sea creatures, the lobster

still presents a puzzle to marine scientists trying to find ways of smoothing out wide fluctuations in yield. Fishermen and conservation officials have been concerned for sixty years or more about possible depletion of lobster stocks, but thus far biologists have been forced to admit their inability to suggest a successful long-range management program.

One thing becomes increasingly clear from research, however. Lobster hatcheries are not the answer to the problem. Instead, more careful life-history and lobster population studies appear to be the most useful direction of research.

Pride of New England

Mystery or not, and erratic in life habits as he may be, the lobster is still the pride of New England. Maine residents, for example, reject the common names of "northern lobster," or "American lobster," and insist that the name is "Maine lobster."

To them *Homarus americanus* is *the* lobster, with other creatures not deserving even the name. They feel so strongly about this, in fact, that in the last Congress a bill was presented which would have prevented any other sea creature going by the name of lobster. This would have made it unlawful for such well-known animals as the Florida and other spiny lobsters to be sold under this name, and would have prevented the squat lobster of Chile being so named in the Amer-

AFTER LOBSTERS HAVE BEEN BROUGHT TO THE DOCK *they are kept alive in crates and "cars" submerged in clean, cold sea water. But they must be shipped promptly, because they are cannibals. A lobster which sheds while surrounded by his voracious fellows is doomed. Kept long enough together, a group of 100 lobsters would eventually become one large lobster. (Maine Department of Sea and Shore Fisheries)*

ican market. Fortunately, the bill failed to survive committee treatment.

"*Homarus mainensis!*"

The pride Maine feels in this most famous of its products is also revealed in the suggestion of one of its foremost conservation officials that "...it is quite proper that the term *Homarus mainensis* [instead of *Homarus americanus*] be used to distinguish those Maine lobsters taken within Maine's territorial waters from those Maine lobsters taken in Canadian or other northwestern Atlantic waters," —a casual tampering with the strict and hoary rules of scientific nomenclature which would leave taxonomists badly shaken!

Maine is the center of lobster production in the United States, and its concern with this resource is understandable when we find that it accounts for a sizeable portion of the wealth of that rocky state. Over 6,000 fishermen have licenses to capture lobsters in Maine and they have produced an average of about 22 million pounds in recent years, representing new wealth of $9 million. This value is greatly increased when we add the costs of processing, packing and distribution.

Employs Most Fishermen

All of New England reaps the lobster harvest, which is the third most valuable marine resource of the area, and employs more fishermen than any other. Lobstering is virtually the sole support of many coastal villages of the northeast states, and their welfare blossoms or withers with production and price of the lobster. Massachusetts follows Maine in yearly production, trailed by Connecticut and New Jersey.

Canada produces more lobsters than the United States, averaging landings of 50 million pounds in recent years. Because of its high unit value, the lobster is the third most valuable marine creature of all Canada, following cod and salmon. Henly Harbour, Labrador, is the northernmost known range, with Cape Hatteras, N. C., the southern limit. The lobster is economically important from Newfoundland to New York.

Like Sandy Bottom

Years of observation have revealed some of the secrets of lobster behavior. Scientists have found that lobsters live in depths of about one fathom out to the edge of the continental shelf, although most fishing takes place in water less than 30 fathoms deep. Lobsters like rocky or sandy and muddy bottom. They seek the rocks when they are shedding, since they need protection while their new shell hardens. They seem to congregate in bigger groups on sandy bottom, and move more here than when they are among the rocks.

Lobsters are not great wanderers by nature. Tagging has shown that they move only a few miles—perhaps five at most—up and down the coast, although they may have a regular pattern of offshore-onshore migration. In the fall, as the temperature drops, they seem to move into deeper water to escape the cold shallows; in spring they return. The larger individuals move about the most.

Because stale fish is commonly used as their bait, lobsters are mistakenly regarded as primarily scavengers. Actually they prefer live food —fish, clams, mussels, and sea urchins. They are especially fond of crustaceans — particularly other lobsters! Their strong cannibalism is the cause of one of the greatest difficulties lobstermen encounter. Lobsters are usually sent to the market alive, and thus must be kept in pounds or holding tanks. A lobster which sheds while surrounded by his voracious fellows is doomed. Kept long enough together, a group of 100 lobsters would eventually become one large lobster.

Man is Chief Enemy

Lobsters, in turn, are the prey of several creatures besides other lobsters. Man is their chief predator, but even the adults form the dinner of big fish, especially cod, tautog, skates and dogfish. The young are gobbled up by the million by hundreds of sea creatures, and it is the lucky lobster indeed which reaches adulthood.

A few hoary individuals beat the odds and survive to exceptional size. Most lobsters caught are about 9 to 10 inches long and weigh about a pound. Dr. F. H. Herrick, the famous authority on lobsters of a half century ago, made a list in the early 1900's of authenticated records of 13 champion lobsters weighing over 20 pounds. The Smithsonian Institution has a 25-pounder, while the American Museum of Natural History in New York City has preserved a giant weighing 34 pounds. It was caught in 1897 off Atlantic Highlands, New Jersey. The all-time champion lobster weighed the prodigious total of 47 pounds and was caught as recently as 1935 off the Virginia Capes.

HOW BIG DO LOBSTERS GET? *One answer to the question is this 9¾ pounder, caught at 200 to 400 fathoms off the New England coast. But it is a mere pygmy compared to the all-time champion, weighing a prodigious 47 pounds, taken near the Virginia Capes in 1935. Most lobsters caught for the market, however, are nine to ten inches long and weigh about a pound. (U. S. Fish and Wildlife Service)*

Coy About Their Age

Lobsters are coy about their age. Unlike fish, they do not have scales or bones with tell-tale rings by which age can be estimated, so biologists are hard-pressed to make accurate determinations of the age of the lobster. By tagging, and other indirect methods, however, it is estimated that lobsters are about five years old when they first spawn, at about 9-10 inches in length.

LOBSTERING IS RUGGED BUSINESS, *but in Maine some of the women enjoy fishing a few dozen traps. Traps are set from fifty feet to miles apart, in water from five to fifty fathoms (30 to 300 feet) deep. While most traps are made of wood, plastic-covered wire traps are among the new designs being tested. (Maine Department of Sea and Shore Fisheries)*

The Paul Bunyan types mentioned earlier are supposed to be as much as 100 years old. Probably all of these very big individuals were males, since they grow faster and larger than females. This is because the female sheds its shell only every second year after achieving maturity, while the male, a little more carefree about its reproductive duties, molts (and therefore increases in size) once a year.

Before the female lays her eggs she molts her shell, and while in the helpless soft-shell condition she is unable to resist the amorous advances of the male. He turns her on her back and transfers a sperm sac into the seminal receptacle on her abdomen.

Eggs Carried a Year

This sperm can remain alive for as much as nine to ten months. When the eggs are mature the female turns on her back, rolls up her abdomen and extrudes the eggs. They are fertilized as they pass the seminal receptacle and are attached to the swimmerettes on the female's underside by a sort of glue. This spawning act takes place in summer and the eggs will now be carried until the follow-

ing summer. During this time they will change from their dark green, almost black color to a light gray. Now the tiny embryo can be seen, and the eggs are ready to hatch.

Hatching takes place at night or during dark days. The female encourages the hatching by vigorous shaking of her swimmerettes. The larvae come off in clouds and swim immediately to the water surface. They molt soon after hatching; a second molt occurs in a few days, a third within ten days and a fourth twenty days after hatching. Only now do the young assume a familiar lobster-like appearance, and only now do they seek the bottom, where they will spend the rest of their days.

Can Produce 100,000 Eggs

Thus the female reproduces every second summer, carrying the eggs one year, shedding, mating and spawning the second. As she grows, the number of eggs produced increases, growing from the 10,000 or so at ten inches to double that number at twelve inches; two more inches of length again doubles egg production to 40,000 and the biggest females of 15 to 16 inches in length produce nearly 100,000 eggs.

Once Used for Fertilizer

Conservation of lobster resources has long been a worrisome job for scientists and government officials. Like many another marine species, the lobster has experienced great fluctuations in catch.

There are the usual tales of abundance in "the good old days." They were so plentiful in the 1860's and 1870's, we are told, that a "sport" fishery existed, employing cod hooks on the end of poles, with which lobsters could be snagged among the rocks. After heavy storms, lobsters were sometimes washed ashore in windrows, and their carcasses were carried to fertilize nearby fields.

A Lobster for a Penny

Lobster fishing was profitable in the early days even though the price in colonial times was only "a penny each," apparently regardless of size. Landings rose rapidly, but reached their maximum very early. The peak production came many years ago in the United States, when over 30 million pounds were landed in 1889. After that the catch fell rapidly, to a low of nine million in 1933. In recent years it has risen again, but has not regained the levels of the 1880's.

The reduced catch is usually regarded as a result of over-eager exploitation. Actually, while overfishing may be an important factor, changes in marine environment, reducing food supply, encouraging predators and otherwise diminishing favorable conditions undoubtedly are also much to blame.

On the theory that fishing reduces the spawning stock dangerously, most conservation measures have imposed size limits (both minimum and maximum), and closed seasons, and forbidden the capture of egg-bearing females. Artificial propagation has also been popular.

In Connecticut, lobsters less than 3-1/8 inches carapace length (9

inches total) must be returned to the water, while in Maine the minimum legal size is 3-3/16 inches carapace length. (The carapace is that part of the body in front of the tail.)

This provision is supposed to allow each female to spawn at least once. Obviously the reason for this is based upon an assumption that insufficient eggs are produced.

A recent article on the conservation of lobsters in Connecticut stated "...it is clear that... lobsters must be given a chance to breed at least once before harvesting them... Each female returned represents 5,000 to 10,000 more fry added to our waters at its first breeding season."

Actually, this need is not clear at all, and the theory is only valid if good evidence is available that shortage of larvae is the controlling factor in lobster abundance. There is, in fact, no good evidence that this is so. Only two larvae from each spawning need survive to reproductive size to maintain the population at a given level. Conditions of survival—food,

IN CANADA, EVERGREENS *are sometimes used as markers. Trees make a satisfactory substitute for the painted buoy-type marker where all the trapping in an area is being done by one person, or a group working together. Also they are cheaper. (National Film Board of Canada)*

predators, currents, temperature and other sea conditions—probably determine this more than the initial number of baby lobsters. There are probably adequate supplies of spawn at even low levels of adult population size.

"Optimum Size" Theory

This is not to say that the lobster populations do not need protection from excessive fishing, nor that minimum size limits are not a valuable control measure; it is highly likely, however, that the virtue of size limits is in reducing fishing effort and in allowing lobsters to reach the "optimum size." This is the theoretical size where increase in weight of the population by growth just balances removals from the stock by death. It is the size, therefore, where the greatest weight of lobsters can be obtained from the population.

Maximum size limits, such as those imposed in Maine, are harder to defend than minimum limits. The theory here is that since egg production increases on a geometric scale, with large females producing up to ten times the number of eggs as the first spawners, the number of larvae can be greatly increased by protecting these oversized animals. Again the need for more larvae comes under serious doubt, with the evidence being against it.

Furthermore, the older the lobster, the more likely it is to die soon, so that it should be kept and used when it is caught, to avoid waste through death.

What About Hatcheries?

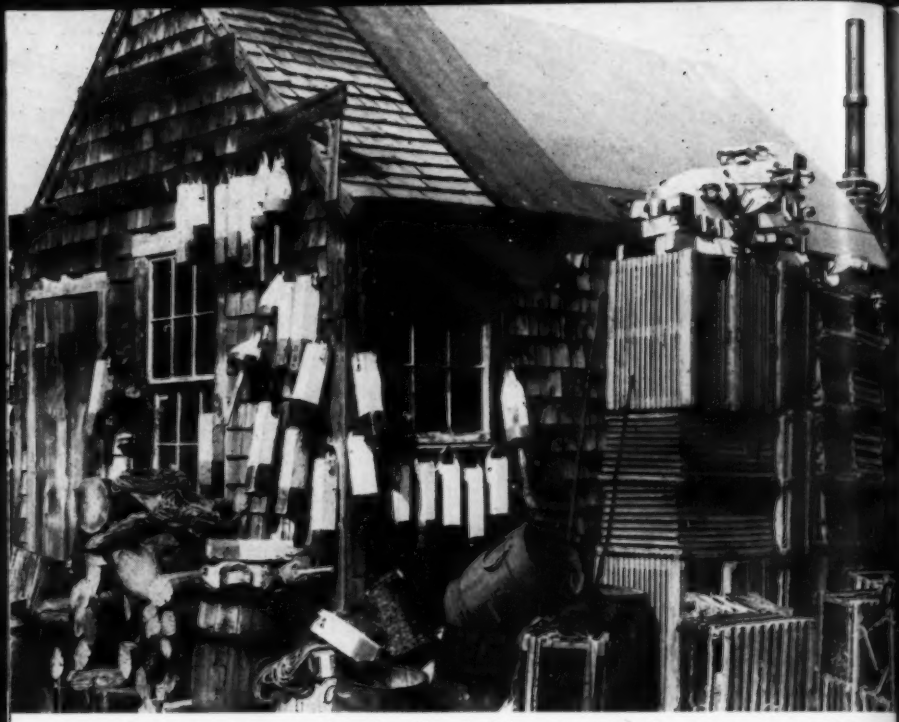
Then we come to lobster hatcheries. It is a truism that when a marine resource shows signs of reduced yields, the first reaction is to demand artificial propagation. This is undoubtedly a carryover from our barnyard experience, where we have learned the value of raising animals under the protection of humans, with adequate food and shelter, and safety from predators.

Unfortunately this ignores the differences between raising young mammals or birds, where survival is so high that only a very few—perhaps ten at most—young need to be produced each year, and raising fish or marine invertebrates, where tens of thousands or even millions of young must be spawned because of the enormous hazards facing them in the sea. Since mortality between egg and adult in most marine animals is 99.9%-plus in nature, fantastically large numbers of young must be produced to maintain the stocks—numbers greatly exceeding those which can be turned out by hatcheries.

Idea Dies Hard

Even when young are raised in hatcheries to relatively advanced stages, thus perhaps increasing survival in the early life of the animal, the hazards facing them when they are finally released are still very great, and the numbers set free are an infinitely small fraction of the number required to affect population size.

Most biologists and conservation officials realize the futility of marine hatcheries, including those for lobsters, but the idea dies hard. Lobster hatcheries were started in the early 1900's, the one at Boothbay Harbor,



ORDERLY CONFUSION *best describes the lobsterman's shack, common to most Massachusetts seaports, and one of the most favored subjects for artists and photographers. Each lobsterman has his own individual markings in color on the wooden buoys like those hung on the walls. Shape of the slatted traps varies a little in different regions. (Massachusetts Department of Commerce)*

in the state of Maine, now closed, being the oldest. In Connecticut fishermen are paid to bring gray berried females (those carrying ripe eggs) to the hatchery. Here they are held until the eggs hatch, whereupon the larvae are placed in wooden boxes, about 3,000 to the box. Water is circulated and the larvae are fed every two hours with a tablespoonful of "liver soup" (finely ground beef liver) or ground-up mussels.

The fry supplement this fancy diet by feeding enthusiastically on each other, and at best only about a third of them reach the fourth, "diving" stage, when they seek the bottom. Then they are released to fend for themselves. Connecticut releases about half a million larvae per year—a small amount indeed compared with the vast numbers produced by the wild population. It is no wonder that Maine officials say sadly, but with a certain amount of restraint, "—the value of lobster culture as a practical conservation technique has not been definitely established." Recently lobster hatcheries have been closed in Maine.

Research May Yield Answer

A more profitable scientific approach to lobster conservation is now being made in most areas, involving careful research into life history. Measurements of growth rates, death rates, fishing rates, as well as collection of information on the influence of changes in temperature, salinity, currents, and other sea conditions on the numbers of lobsters will some day yield the information necessary for a rational management program.

Meanwhile the public appetite for lobsters continues unabated. To supply this demand, fishermen, one or two to a boat, pursue the lobster, mostly with the time-honored method of trapping.

MOST LOBSTERS ARE SHIPPED ALIVE, *but some are packed into cans, and a few are quick-frozen. An electronics manufacturer has been conducting tests using radar, or microwave energy, to preserve both fresh and cooked foods, including lobster. Held under vacuum at below-freezing temperatures, the food is then treated with microwaves. (National Film Board of Canada)*

LOBSTER, THE MONARCH OF THE DINNER TABLE. *The end result of conservation, trapping, shipping, wholesaling and retailing is this delectable dish, with the traditional melted butter, potatoes, peas and other "trimmings." There is no simpler food to prepare than lobster. You simply place the lobster in a kettle of briskly boiling, salted water, and let it boil for 15 to 20 minutes, depending upon the size of the lobster. (Maine Department of Sea and Shore Fisheries)*

"Free-for-all" Prevented

Brought to shore, the lobsters are usually put into "live cars," floating pounds, where they are held until they can be sent to market. Because they are pugnacious, and will injure each other if allowed full use of their formidable weapons, their claws are rendered harmless by inserting a small wooden plug in the claw joint. Some live cars hold as many as 2,000 to 3,000 lobsters.

Most lobsters are sold alive, even at the retail level, requiring careful handling and shipping methods. This has resulted in the development, with the help of science, of really remarkable and ingenious shipping techniques. Lobsters breathe by means of gills, which are located under the big curved flaps covering the thorax. As long as these gills are kept moist the animal can survive out of water up to three weeks and withstand shipment over thousands of miles.

Shipping Techniques

Until recent years live lobsters were usually shipped in boxes or barrels packed in ice. Careful shippers always separated the ice in a different compartment from the lobsters, to avoid ill effects of the fresh water resulting from the melting of the ice. Improved techniques have now been developed for live shipment, avoiding the weight of iced barrels and the necessity for re-icing en route.

Cardboard boxes have been used, packed with ice and wood shavings; also insulated plastic containers. Some companies use hermetically sealed cans for live shipment of lobsters. Inside the cans treated water, oxygen and other materials absorb the waste products. The lobsters are guaranteed by the company to remain alive six days and may last sixteen, if the water is kept at 40°F.

The design and maintenance of holding tanks in restaurants and other points of sale are highly specialized activities. With a high-priced item like lobster it is worthwhile to go to considerable expense to obtain the best quality of tanks, artificial sea

water, filters, temperature controls and the other paraphernalia necessary to keep the creatures alive—if not happy.

Research in Canada has shown that water temperature, saltiness and oxygen content are the three factors of importance, and if any two of these changes abruptly, or go outside the range of tolerance, death results.

Transplanting Fails

It is natural to try to transplant a valuable and highly sought animal like the lobster to other parts of the world, and attempts were made as early as 1874 to introduce them to the Pacific coast. In that year and in 1879, 1888, and 1899, 355 adults and 104,000 larvae were released in California waters, and 233 adults in Puget Sound. These disappeared without a trace, as did 24,572 adults introduced into Puget Sound and 1,532 in Yaquina Bay, Oregon, between 1906 and 1917.

Several attempts have also been made to take lobsters from waters of the Maritime Provinces to those of British Columbia, but so far none of these innoculations "took." Hungry gourmets will still have to depend, then, on New England and the waters of eastern Canada for this salty knight-in-armor, the northern lobster.

Shrimp Travels Two Thousand Miles!

Most tagged shrimp are spotted by fishermen in waters not too far from where the tags were applied. But two markers, placed by scientists of The Marine Laboratory, University of Miami, for the Florida State Board of Conservation in Florida waters, have been found in such distant points as New York City and Athens, Georgia! At first reading this seems an impossible distance for a shrimp to travel. But here is an explanation.

A shrimp tagged on February 5, 1959, about nine miles south of Loggerhead Key lighthouse in the Dry Tortugas, turned up in the kitchen of Mrs. Patricia Muzzik, of Bronx, N.Y. She returned the tag to The Marine Laboratory with the comment: "I had already boiled the shrimp before I found the tag." She hoped the boiling did not injure the tag. It didn't.

Another tag, returned to The Marine Laboratory, was found in the kitchen of an American Legion post in Athens, Georgia, by Mrs. J. H. O'Kelley, manager of its dining room. She wrote that she bought the shrimp, 25 pounds of them, at Wolfong Brothers, at Athens. This shrimp was tagged on January 21, about 12 miles northwest of Key West.

EARLIEST METHOD OF CAPTURING SMALL WHALES *was to wait until they entered a fjord, then run a net across the opening, and take them with hand harpoons. Sometimes, as was the case here, the whales in their fright and panic strand themselves upon the beach, and are easily captured. These are bottlenose whales. (Black Star)*

Norway's Small Whales

By AGE JONSGARD AND E. JOHN LONG

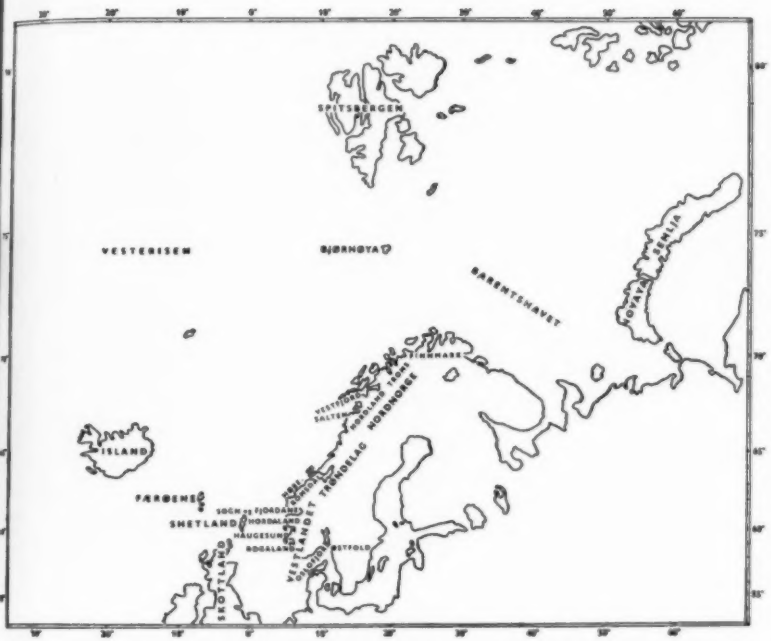
THE ADVENTUROUS DAYS of Captain Ahab and the great white whale, Moby Dick, may be no more, but small whale hunting is still a profitable and at times very exciting occupation along the rocky coasts of Norway, where some of the first whaling operations in history took place several hundred years ago.

Whaling methods, even in the taking of small whales, have meanwhile greatly changed. Pioneer whaling operations took place entirely within the narrow sounds or fjords during migration periods. Then the whale, so to speak, "sought the hunter."

Here is how it was done. A watch was set at the narrow inlet of a fjord, and, when an unsuspecting whale swam through in pursuit of herring schools, a stout net was promptly drawn across the fjord's mouth.

Fishing by Bow and Arrow

Thus trapped, the smaller species, and dolphins, were easily captured with hand harpoons. But even the



RANGING AREA OF THE SMALL WHALES. *This map, from the* Norwegian Whaling Gazette, *indicates the principal fjords and offshore islands where small whales have been hunted for many years. A Royal Norwegian Decree limits the hunting of the little mammals in Norwegian waters to two periods each year.*

little piked whale proved too obstreperous to be taken by such simple means. It stayed well out from shore and had to be approached in rowboats. Archers in the bow shot poisoned arrows into its thick hide, and then had to lay to their oars with a vengeance to escape thrashing tail and fins.

The arrows caused blood poisoning, and, after a few days, the whale was so weak that it could easily be dragged ashore. Meat and blubber were then divided between hunters and landowners according to fixed laws. From the inflamed sores of killed animals new poison was obtained for future use. This primitive method was used in fjord hunting until about 1890, after which the little piked whale was killed with Krag rifles fired from boats and from shore.

Harpoons Replace Arrows

Meanwhile, both Norwegians and Scots had ventured out into the storm-tossed wastes of the northernmost Atlantic, between Iceland and Spitzbergen. Here the bottlenosed whale could be hunted in conjunction with sealing operations. Harpoon guns, which greatly simplified whale hunt-

EARLY WHALE HUNT IN FULL SWING. *An artist's sketch of the mad scene in a fjord of the Faeroes Islands, a Danish group north of Scotland, as boats stampede the little whales into shallow water, just as Scandinavian whalers did centuries ago, and as Newfoundland "pothead" whalers do today. (Brown Brothers)*

ing, were mounted on rowboats sent out from mother ships. By the mid 1890's, whale catches ran as high as 3,000 per season. About this time, too, the more adventurous whalers extended their operations to the fjords of Spitzbergen, in quest of the white whale.

What is a Small Whale?

Before considering modern Norway's small whale industry, which dates from the late 1920's, let us define "a small whale." In Norway this means a fully-grown whale less than 12 meters (43 feet) in length. Therefore, of the 65 species of toothed whales, all but the sperm or cachalot *(physeter catodon)* can be termed "small." Of the ten species of baleen whales, however, only two rightly may be called small—the little piked whale (*Balaenoptera acuto-rostrata*) and the pigmy right whale *(Neobalaena marginata)*. The pigmy right we can ignore. It does not occur in the northern hemisphere, and has no present economic value.

In addition to the piked whale, the other subjects of pursuit include the bottlenosed whale *(Hyperoodon ampullatus)*, the killer whale *(orcinus orca)*, the white whale (*Delphinapterus leucas)*, the pilot whale *(Globicephala melaena)*, the white-sided dolphin *(Lagenorhynchus albirostris)*, and the common porpoise *(Phocaena*

phocaena). Today's whaling industry, however, is more interested in the four whales than the dolphins or porpoise named above, but all of them have value, as does also the basking shark *(Cetorhinus maximus)* and the common tunny *(Thunnus thynnus)*, which are mentioned with the mammals because they are being taken with the same types of harpoon guns and other equipment.

From Shark to Whale

In fact, the people of the Mφre area, one of the principal fishing districts along the Norwegian coast, became interested in whaling through the development of basking shark and tunny fisheries in the late 1920's. When the harpoon rifle became available, the Mφre fishermen devised a technique for tunny that proved to be equally effective in the capture of small whales at sea. Fishermen in whaleboats first fastened glass floats or balloons of sailcloth to the harpoon line. As soon as the harpoon had been shot, the floats or balloons were quickly thrown overboard. The fish ran away with them, of course, but not for long. Within a half hour the quarry was generally so exhausted that it could easily be pulled in by the fishermen.

When the method was applied to whaling, and the whale tried to dive, the floats or balloons revealed his position. Boats could then move up to give the *coup de grace* as it surfaced again. Previously whalers had paid out up to 300 fathoms of line, whose end was made fast to the boat. If the harpoon had not reached a vital spot, the whale was master of the situation, not the crew. A boat might be dragged along for hours and the predicament become so hazardous that the line had to be cut, losing both whale and gear.

Dead Whales Sink

The first boats used by Norwegians in whaling were small, ranging from 25 to 40 feet. It was soon apparent that larger craft, equipped with a mast and winch, would be necessary. Either that, or pass up the little piked whale, which sinks like a rock when killed. By the end of the 1930's many decked boats, complete with powerful winches, and from 60 to 80 feet long, were operating out of Mφre and North Norway.

In the beginning harpoon guns were mounted in the bow on a bollard of wood, secured by three or four iron stays. Early whaling boats, however, were not built to withstand the recoil of a gun. After a few rounds, the gun mounting sometimes worked loose, and the weapon became more dangerous to the gunners than to the whale. By the mid 1930's, as whaling became a more established industry, boats and guns were improved to a point where this risk was eliminated.

Shock Absorbing Gear

Even after whales had been killed, they became lost in stormy weather, when the stoutest of lines would break as the ship pitched and rolled. To take up some of the strain, the whalers worked out a spring device, either on the mast or along the rail, which was linked to the lines by a block. The main (wire) line ran from the winch to a block at the top of the mast in one such arrangement. The block was

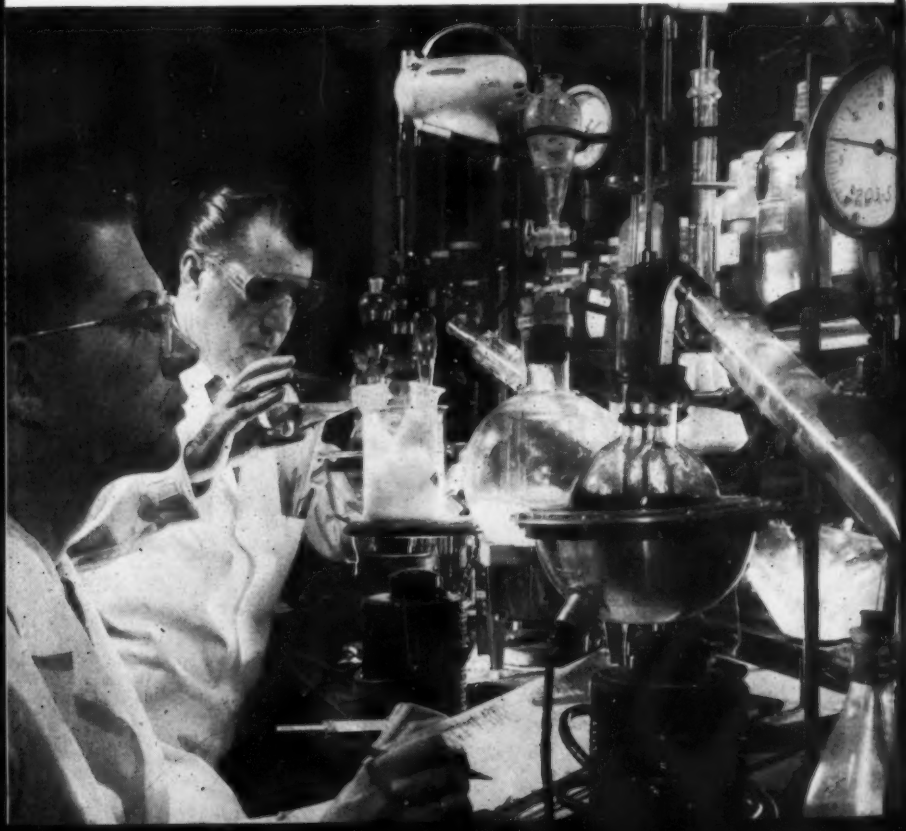
coupled to a spring device in such a way that sudden jerks, caused either by the whale or the rock-and-roll of the ship, could readily be absorbed.

Big factory ships, used in hunting large whales, have openings and ramps in the stern, and the whole carcass of the whale can be brought aboard for flensing, but the small whaling vessel has no such facilities. Even small whales once had to be towed ashore for processing, and the meat and blubber reloaded on the ship, a gruelling and time-consuming job.

Danger of Capsizing

When decked boats came into use along the Norwegian coast, efforts were made to haul the little piked whales on board with a tackle on the mast. By making a rope fast to one

SCIENCE SEEKS NEW USES *for whale products. Research being conducted at a Minneapolis, Minn., laboratory indicates that alpha-olefins from whale oil may be a building block used by tomorrow's chemical industry. This is a switch, because it was the laboratory, by substituting kerosene for ordinary whale oil, petroleum lubricants for sperm oil, and paraffin for spermaceti, that almost brought an end to the whaling industry. Perhaps one day, however, whales may be bred as "the cattle of the sea," to obtain by-products needed by chemists. (Archer-Daniels-Midland Co.)*



IN CONTRAST TO *the huge factory ships operating in Antarctic waters, motor vessels are quite adequate for the small whale industry of the North Atlantic. After it has been harpooned and brought alongside, a whale is taken on board by special tackle, then is cut up and stored under ice in the hold. This assures that both quality and color of the meat are maintained. Meat is the most profitable product of the Norwegian industry. (Black Star)*

of the flippers of the whale, a winch could raise it partly out of the sea. Men in small boats then cut the whale's body into 3 or 4 parts, without severing the backbone. As each part was flensed, another section of the whale was pulled on board. In

rough weather, the list given to the ship by the overhung whale could be dangerous.

A much better method of processing was discovered in the late 1930's. By widening the opening in the rail on one side of the ship, and rigging a boom in an oblique position on the other side, a special tackle could slide the whole whale on to the deck of the ship, although the head and tail generally projected overboard. The ship could then go after other whales, if the weather were fair, while the crew cut up the one on deck. If hunting was particularly good, harpooned whales were filled with air by a hollow lance, connected by a rubber tube to the ship's air tank. Marked with a flag, they were allowed to float until the deck was clear.

Some Norwegian boats of the "small whale fleet" can operate three weeks or longer at sea. They are stocked with ice before leaving port. After whale meat is cooled on wooden grids on deck, it is placed in the hold and covered with ice. Thus both the quality and the color of the meat is retained.

Whale Steaks

What makes the industry profitable? Chiefly the sale of whale meat. While the average Norwegian is not too "whale - meat minded," choice steaks find a ready market, particularly in winter months. But a more important outlet is for animal food. Fox farms find that small whale meat produces fine pelts. It is believed that frozen whale meat might be sold abroad if a marketing service could be set up.

No Decline in the Fishery

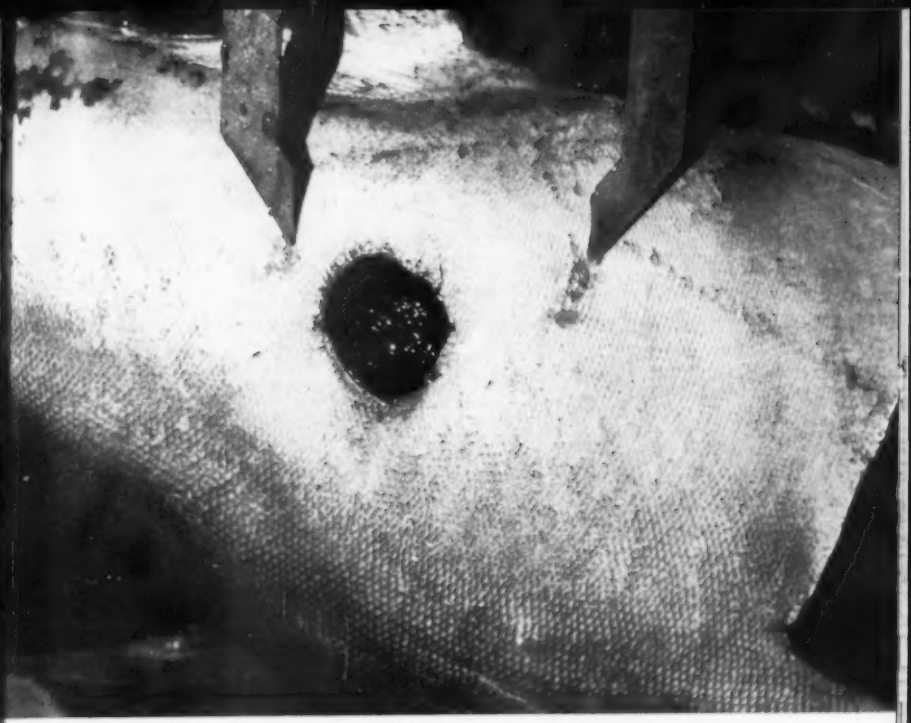
Meanwhile, surveys of Norwegian waters show no serious diminishing of either small whales, sharks or other quarry of the whaling industry, although they may not occur with equal frequency in the waters along the whole of the Norwegian coast and fringes of the Arctic Ocean. World War II gave all the denizens of the depths a breather. Since then the hunting season has been regulated by Royal Norwegian Decree. The permitted hunting period is now from 15th of March to 30th of June, and from 22nd July to the 14th of September in Norwegian waters.

License to Whale

Of interest to biologists is the requirement that each hunter of small whales have a license. The license, in turn, calls for a report on each whale captured, giving such valuable statistical information as where and when the whale was taken, and its species, sex and length. While such information cannot be free from error, it will provide the basis for much better understanding of one of the lesser known industries and biological groups of the sea.

Where the Atlantic is Fresh

The Amazon River's discharge into the sea is greater than that of the world's next three largest rivers combined. In fact, the Amazon freshens Atlantic waters for more than 190 miles offshore.



WHO OR WHAT *is using the yellowfin tuna as a target, and almost always in the same spot? Marine scientists are seeking an answer to this puzzling affliction to one of the most valued deep-sea fishes, and speculation concerning its origin ranges from giant spearfishes to bacteria invisible to the naked eye. (U. S. Fish and Wildlife Service)*

Pelagic Puzzle

By E. S. IVERSEN
The Marine Laboratory, University of Miami

MANY TIMES, while fishing for tuna in tropical or subtropical waters, one angler has turned to another to ask what causes the peculiar wound or sore commonly found on the sides of the yellowfin tuna *(Neothunnus macropterus.)* The sore is easily identified in advanced stages, because a hemispherical plug of skin and flesh is missing and the flesh beneath inflamed.

More often than not, the second angler will dismiss the question with some comment about a spearfish making a thrust at the tuna and misjudging. Or he may say that he honestly does not know. This is the answer which a scientist, too, must give.

Noticed Also on a Dolphin

Recently Colonel J. K. Howard, a member of the Board of Trustees of

the International Oceanographic Foundation, and research associate of The Marine Laboratory, University of Miami, received a letter from Mr. Douglas Dryden, of Southern Rhodesia. Mr. Dryden described this affliction of yellowfin tuna in waters near the island of St. Helena and added that about 25 per cent of the yellowfin were afflicted. He noticed it also on a dolphin (*Coryphaena hippurus.)*

Members of the scientific staff of the Pacific Oceanic Fisheries Investigations, a branch of the U. S. Fish and Wildlife Service with headquarters in Honolulu, have for some time observed this condition on yellowfin tunas in the Central Pacific, around the Hawaiian Islands and along the Equator. Although the wound is less prevalent in the Pacific than in Atlantic waters, it appears to be very similar, and therefore may be caused by the same organism.

Culprit Not Yet Caught in Act

The reader may ask, "Why the concern over this matter?" He may reason that the cause cannot be too important when the wound apparently does not kill the fish and only a small portion of the flesh is lost as food. But there is always the matter of scientific curiosity. Just as many of us enjoy a good "who-done-it," the scientist enjoys a good puzzler.

In the present case, the puzzle is difficult to solve because the culprit has not been caught in the act, and has left very few clues. Even if the evidence is very scanty, however, it is possible, through inference, to suggest a causative agent. First of all, it seems fair to eliminate the possibility that it is caused by a typical cell growth, because of the regularity of the shape of the wound and its more or less fixed position. So this brings forward a host of organisms, from the giant spearfish down to bacteria invisible to the naked eye.

Eliminating the Spearfish

Spearfishes come to mind right away because of the circular shape of the wound, about the size of a spearfish's spear, and the fact that these fish are known to eat tuna. But if the wounds were caused by thrusts, they would be more irregular, some deeper than others, and would occur in various places on the tunas. But the wound or sore is always in about the same place—close to the anal fin—and the diameter is generally about 1½ to 2 inches, with a depth of an inch or so. The spear of a spearfish has been known to penetrate deeply, sometimes plowing through the heavy planking of good-sized ships.*

Scientists who have made a study of the food and feeding habits of spearfishes feel that the stabbing of prey is unintentional. The spear is believed to streamline the fish so that it can pass through the water at terrific speeds and thus overtake and capture prey.

Notwithstanding this body of opinion, there are eyewitness accounts of spearfishes spearing tunas and dolphins. Also fish have been taken from the stomachs of spearfishes with holes that most certainly seem to be made

*See "The Fisherman Fished" By Charles E. Lane, *Sea Frontiers*, Vol. 2, No. 1, March, 1956.

ONE OF THE "SPOT MYSTERIES" *shows up in a Honolulu fish market. It was noted on the yellowfin tuna, fifth from the bottom, left row, during a Pacific Fisheries Investigation. Other fish on the market floor include marlin and big-eye tuna. (U. S. Fish and Wildlife Service)*

by spearfish. The regular shape and depth of this sore, and the evidence that spearfishes only occasionally use their spears in food getting, however, tends to eliminate the spearfish as a cause in this instance.

Lamprey Marks?

The finger of suspicion next points to the lamprey. The lamprey is well armed to inflict damage, and has a bad reputation in the world of fishes. It is known, for example, that salt-water lampreys attach themselves to whales, porpoises, and salmon, and thus obtain food and free travel status. Marks or wounds they leave have been described by scientists, but the chief clues are teeth marks. While the tuna wound is about the same size as that left by lampreys, there are no teeth marks. Whales have been stranded on beaches with lampreys still attached, or lampreys have been found swimming in the water in the vicinity of the host. Yet no lampreys have been discovered on tuna freshly caught, nor have any been reported in nearby waters.

Primary Cause Versus "Guests"

Next let us consider the smaller organisms. Parasitic worms would seem to be absolved, because they

would occasionally be seen in contact with the wound, which is not the case. But very tiny micro-organisms occur in the muscles and on the skin of other fishes, and sometimes produce wounds or open sores of the kind found on tuna.

In Japan, for instance, scientists discovered a small one-celled animal called sporozoans in the trunk muscles of yellowfin tuna that cause muscles to become soft and full of pus. Eventually there may be an eruption of this material. This leaves open sores which are invaded by other very small bacteria. It is very likely that bacteria play a role in our mystery affliction, for they have been found in these wounds. But whether they are the primary causative agent, or have just moved in as "guests" when conditions were right, scientists are not yet prepared to say.

Some copepods *(Pennella* sp.) are blamed for sores on fishes and aquatic mammals because they actually embed part of their bodies in the host, and permit bacteria and other micro-organisms to enter the flesh. These copepods have not been seen on the Pacific yellowfin, at least.

Then There Are Sea Lice

Another form of copepods, sea lice, attach to the skin of fishes, including yellowfin, and erode away the fishes' protective slime, thus clearing the way for bacteria and others to invade and enlarge the wound.

So there is the evidence in the case. Scientists can absolve only the larger and more obvious suspects, such as the spearfish and lamprey, who thus far have borne an unfair burden of guilt. The sneaky culprit is somewhere among that vast host of tiny parasites or bacteria, about which so much is yet to be learned. Perhaps, after reading this article, some parasitologist may come up with a theory or new evidence that will help us to solve this pelagic, or open sea, puzzle.

Wanted: Dulse Drier

Dried dulse, an edible seaweed, retails at nearly $3,200 a ton. It is plentiful along the rocky coasts of New Brunswick, Canada, and weed gatherers claim they could double their sales if the drying problem could be solved. Dulse now has to be sun-dried, and if the sun fails to shine for a day or so after dulse has been picked, the crop becomes a total loss.

Dulse must be spread on the rocks, and this, too, requires an experienced hand—one who can use a dexterous turn of the wrist when the weed is dropped on the rocks, so that the leaves will not lie flat. Cured dulse is put into transparent bags, each containing about an ounce. Prospects for an inventor who might develop an artificial drying method for dulse appear attractive, because there is a growing demand for the weed, used as a relish and flavoring, particularly in ragouts and other stews.

MARINE ARCHEOLOGY *is a comparatively new science, and special ships and equipment are needed to carry on extensive research in areas beneath the ocean's surface.* Sea Diver II *is the largest and best equipped ship now engaged in this type of underseas exploration. Recently it has been studying the lost city of Port Royal, Jamaica, much of which toppled into the sea during a violent earthquake in 1692. (Photo from Edwin A. Link)*

Exploring a City Under the Sea

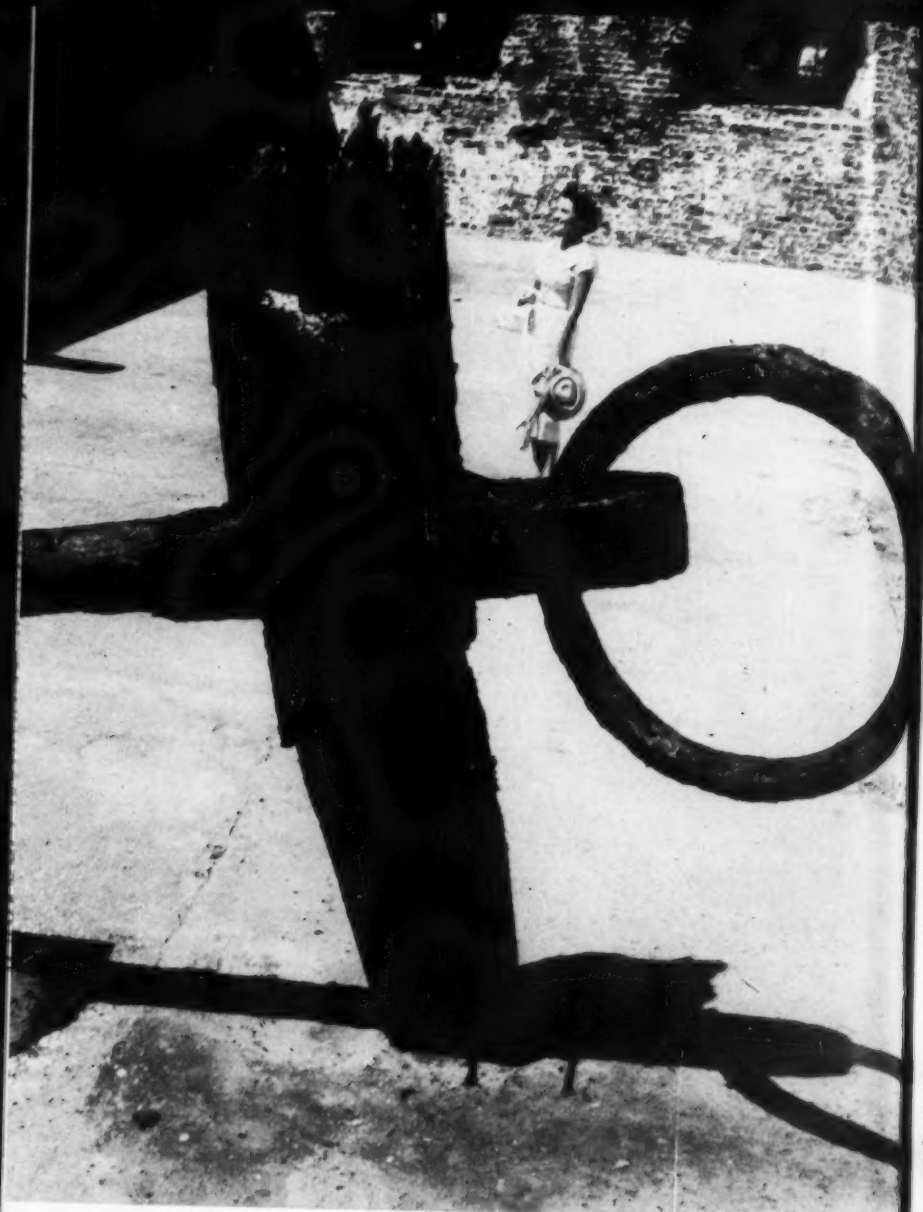
By E. JOHN LONG

BACK IN 1692, a violent earthquake suddenly toppled much of the city of Port Royal, Jamaica, into the sea. From time to time during the past two-and-a-half centuries, divers have brought up relics of this once-thriving community, also known as the "wickedest city in the world."

However, fictionized reports and novels describing houses and shops almost intact under the waves, and of church towers whose bells ring with the tides, can hardly be true. Fathometer tests fail to disclose any structures beneath the water; in fact, about six feet of gravel, silt and clay completely cover the low broken walls and piles of brick which are all that remain of the sunken city.

What Mysteries Below?

Marine archeologists would like to know more about these subterranean ruins and the mysteries they contain.



JAMAICA'S HISTORY *goes far back to the days of Columbus. Port Royal, early seaport and capital, was once a pirate stronghold and "the wickedest city in the world." This anchor recalls the time, too, when Horatio Nelson was commander of nearby Fort Charles, British Caribbean stronghold. (Jamaica Tourist Board)*

Consequently, the floor of Morgan's Harbour is now being subjected to close scientific scrutiny by an expedition sponsored by the Smithsonian Institution and the National Geographic Society, with the cooperation of the Jamaican government.

Leader of the expedition is Edwin A. Link, inventor of the Link Aviation Trainer, and a Life Fellow of the International Oceanographic Foundation. Headquarters are aboard his new 91-foot oceanographic vessel, *Sea Diver II*. Recently launched in Quincy, Mass., *Sea Diver II* is the first large ship designed and built especially for underwater archeological exploration. It contains a wide array of the latest diving gear, and carries on its deck two smaller craft, a launch called *Reef Diver*, and an outboard-motor boat named *Wee Diver*.

Navy Divers to Assist

Included among the select staff of the expedition will be U. S. Navy divers, and other underwater experts, marine archeologists, and Jamaican scientists. Mendel L. Peterson, curator of naval history of the Smithsonian, and Captain P. V. H. Weems, USN (Ret.) of Annapolis, Md., two other members of the expedition staff, believe that the discovery and precise dating of any seventeenth century relics from the site should provide information of great value to historians, archeologists and marine scientists.

Preliminary studies of the harbor floor show that the rather extensive ruins of the old city's lost waterfront lie in about 35 feet of water, beneath which is the layer of mud and silt that has built up during the intervening centuries. *Sea Diver II* is equipped with special dredging machinery which can suck up this debris, and open the way for underseas divers to secure actual relics and data from the ruins beneath.

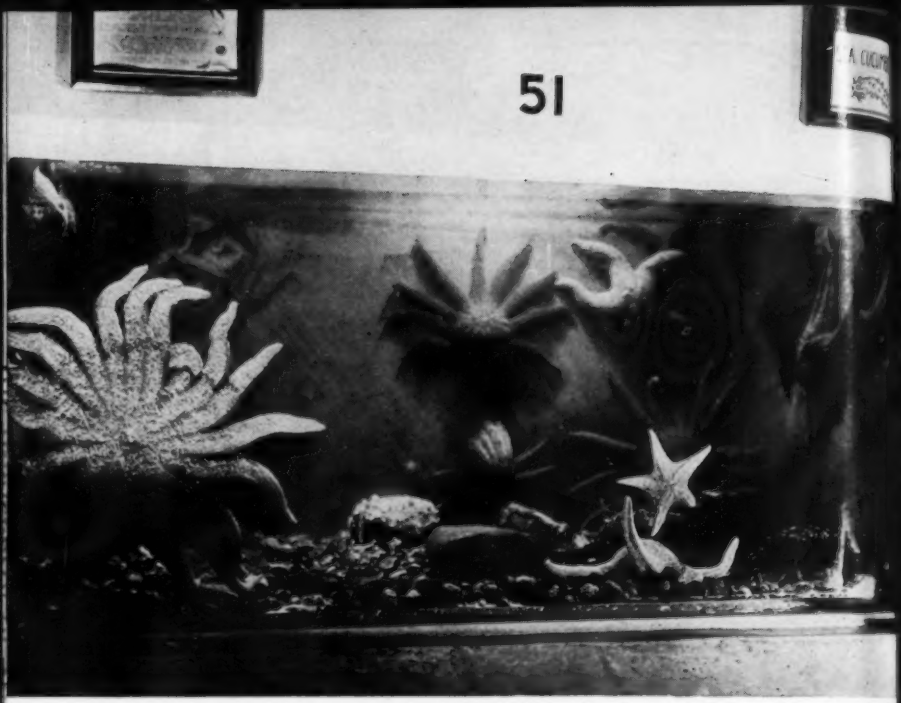
All that remains of Port Royal above water today is a small village on the outskirts of Kingston, Jamaica's capital. Nearby is ancient Fort Charles, which the British naval hero Horatio Nelson commanded before he was twenty-one years old.

Wading Trails To Offshore Reefs

St. John Island, in the Virgin Islands National Park, may soon offer visitors a unique way to become acquainted with its wealth of marine life.

Underwater wading trails of offshore coral reefs are proposed in a report recently submitted to the Governor of the American Virgins by Conrad Limbaugh, biologist of the Scripps Institute of Oceanography in La Jolla, California.

According to the plan, the trails would be in water 3½ feet deep or less, and their courses marked by buoys. Visitors would carry face masks or glass-bottomed boxes to enable them to view the teeming life of the adjacent reefs, including giant sea fans, massive coral formations and hundreds of brilliantly-colored tropical fish.



STARFISH OCCUR *in many sizes and shapes along the shore of the North Pacific. The giant sunflower starfish* (Pycnopodia), *seen at the left, is one of the largest species known, and may reach a diameter of several feet. (E. M. Allen photo)*

Vancouver's Unique Aquarium

By MURRAY A. NEWMAN, *Curator*

DURING THE PAST three years, a fascinated procession of more than a million people has explored a low, modern building in Vancouver's Stanley Park. This is the Vancouver Public Aquarium, Canada's first major institution of its kind—the result of a practical partnership between government, marine enthusiasts and the general public.

Although comparatively new in a city that boasts many cultural and educational enterprises, the Vancouver Public Aquarium has become something of a family institution to the half million people of Greater Vancouver. In 1958, as tourists by the thousands arrived for British Columbia's festive Centennial Year, it became a major drawing card for visitors.

Near Downtown Vancouver

The Aquarium is located in Stanley Park, a semi-wilderness less than two miles from downtown Vancouver. The one-story, concrete structure looks over Burrard inlet, the busy

harbor that makes Vancouver Canada's largest Pacific seaport and fishing center. Surrounding it, under great cedars and Douglas fir, are the buildings of a first class zoo and the scenic driveways that bring thousands of people to the park every fine day.

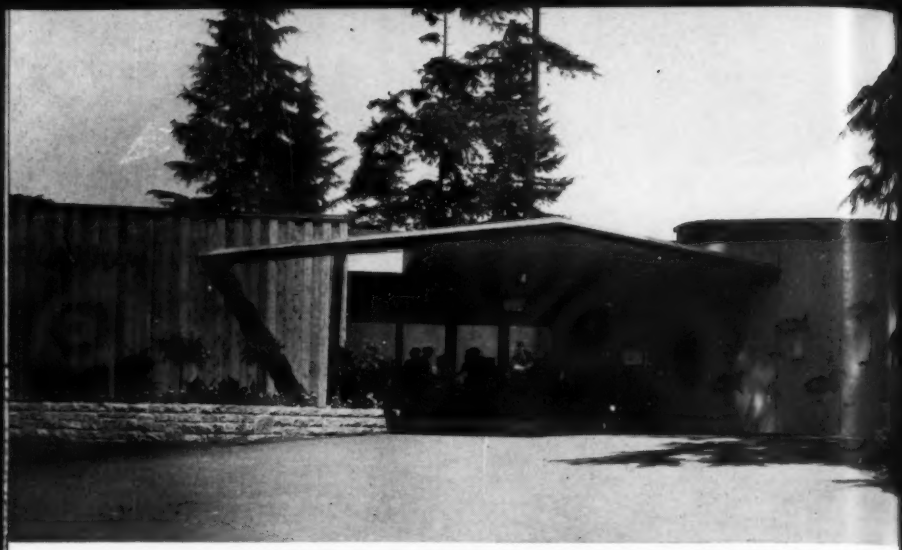
The aquarium is a modern structure, 145 feet long by 99 feet wide. Five years of planning preceded construction, and the attractive but functional design incorporates the better features of other public aquaria of the continent.

The Vancouver Public Aquarium is unique in that it is the result of practical partnership. The cost of construction was paid by three donations of $100,000 each from the city, provincial and federal governments, and the building site was provided by the Vancouver Board of Parks and Public Recreation.

Nonprofit Organization

Actual operation is carried out by the Vancouver Public Aquarium Association, a private, nonprofit organization, headed by a Board of Governors. Half the governors are elected by the membership, the other half

AN AQUARIUM TANK *gives a better close-up of an octopus than can be obtained in its natural haunts. Weighing from 50 to 100 pounds, the adult Pacific octopus has a unique color mechanism enabling rapid shifts from gray to red, according to changes in mood and behavior. Its powerful, bird-like beak is concealed at the point where the radiating lines of suckers converge. (Jack Rushant photo)*



GIANT CONIFERS *of Stanley Park tower over the entrance to Vancouver's modern Public Aquarium. In addition to exhibits open to visitors, the Aquarium also contains research laboratories where university and government scientists carry out investigations of the physiology and behavior of marine animals. (Vancouver Public Aquarium)*

appointed. The appointees are the mayor, two aldermen, three park commissioners, two representatives of the University of British Columbia and two representatives of the Vancouver Aquarists Society.

At the back of the entrance lobby, illuminated by a skylight, an alligator pool is surrounded by tropical vegetation. Around the sides of the lobby are numerous glass tanks which contain frequently changed, special displays of fishes, amphibians and reptiles. Some of the more unusual exhibits have been matamata turtles, Surinam toads, electric catfish and Asian archer fish.

Variety of Waters

The main displays consist of thirty-five glass tanks and thirty-three large concrete tanks having capacities of 400 to 12,000 gallons. These tanks are divided into four systems: tropical salt water, tropical fresh water, cold fresh water and cold salt water. There are three 400 gallon tropical salt-water display tanks and two reserve tanks of the same size. These receive water from a closed system of 5,000 gallon capacity in which the water is maintained at 75°F and continuously passed through a sand and gravel filter.

Evaporation Replaced

The fishes exhibited in these tanks come from tropic seas around the world, particularly from clear coastal waters near coral reefs. Some favorites have been lionfish with long striped fin rays, little orange and blue clownfish, yellow tangs and triggerfish. Because of direct flight connections with Honolulu, many tropical marine specimens come from Hawaii.

The small tropical fresh water tanks are heated by individual electric heaters, connected to thermostats which maintain the temperature between 75° and 85°. The water is clarified by subsand filters using air from a large compressor in the basement. As the water evaporates from these tanks it is replaced by preheated water piped from a thermostatically controlled 300 gallon reservoir in the workspace.

Tropical fishes are selected for display on the basis of different qualifications. It is important to have common species, to show people who have had no experience in fish keeping but who would like to start the hobby. For this reason most of the basic tropicals such as guppies, platies, swordtails, tetras, danios, gouramies and angel fish are shown from time to time.

Some Tropical Oddities

Visitors who are aquarium experts want to see relatively rare and unusual species, such as large discus fish, African polypterus and fresh-water butterfly fish. Perhaps the most interesting fresh-water tropicals are those selected for their unusual adaptations. Among these are African lungfish, flesh-eating piranhas, electric eels, knife fish, upside-down catfish, mouth-breeding cichlids and quite a few others.

The cold fresh-water displays are contained in seven glass fronted concrete tanks. Sturgeon, garpike and other species that prefer intermediate temperatures are kept in water that recirculates through filters on the sides of their tanks, and does not fall below 60° Fahr.

Most native fish species, particularly the many magnificent salmonid fishes, such as steelhead, Kamloops trout, Dolly Varden, Cutthroat trout and Pacific salmon, receive a constant flow of water in an open system. This water comes via the city main from melting snow at the source of the Capilano River, on the north shore of Burrard Inlet. It is very cold and even in summer does not exceed 50°.

The central part of the Aquarium is the cold salt-water section where the fishes and marine life of the North Pacific are exhibited. The system of water supply for this section is a compromise between an open (constantly supplied from the sea and used only once) and closed (recirculated and used many times) system, water being pumped directly from Burrard Inlet five times a week, then recirculated over the week-end.

Water Intake Mechanism

The actual mechanism of water intake is as follows: a 250 foot, 8 inch asbestos cement pipe acts as a syphon from the lowest low tide level to a sump in a pumphouse at high tide level; this water is then pumped by two pumps about 1,000 feet up a hill to the Aquarium building (elevation 130 feet) where the water passes through a sand and gravel filter into three 50,000 gallon reservoirs in the basement.

From the reservoirs three pumps circulate the seawater through the individual tanks where it flows back through the filter to the reservoirs. The return flow is controlled by valves, so that when pumping from the sea the engineer can let the tanks

overflow into drains going out of the building. Since all pipes and fittings are polythene plastic, hard rubber, or asbestos-concrete, and since the pumps are lined with rubber, sea water never contacts metals. This avoids the many problems of toxicity, electrolysis and corrosion resulting from the use of metals around salt water.

Heat Wave Above 60 Degrees!

The American North Pacific Ocean is distinctly different from the American North Atlantic Ocean, and the animals within it require correspondingly different conditions in order to survive in captivity. The North Pacific is uniformly cold, with relatively little variation in temperature. Practically all of its marine organisms suffer when the temperature rises above 60°F. For this reason it is necessary either to refrigerate aquarium water or to pump from the sea often enough to keep it cool. The latter course is followed because more forms can be exhibited with less danger of contamination if the water is frequently replaced.

The marine invertebrates are particularly gaudy in color and varied in structure. Among those commonly displayed are anemones, sea pens, sea cucumbers, sea urchins, starfish, sessile crinoids, snails, bivalves, octo-

UIS AGASSIZ CONSIDERED *the live-ring perch of the Pacific so unusual he placed it in a separate order. e blue perch* (Taeniotoca) *swim ng waving sea anemonies in one of tanks at the Vancouver Public uarium. (Jack Rushant Photo)*

puses, tubeworms, hermit crabs, cancer crabs, spider crabs and tunicates.

Probably the most interesting fishes in the Aquarium are those which are unique to our waters, such as the live-bearing sea perch and the numerous species of sculpius. Undoubtedly the most spectacular animal and the one most popular with our visitors is the large Pacific octopus, a good sized specimen, seven or eight feet in diameter.

"Fairtry" Inspires Successors

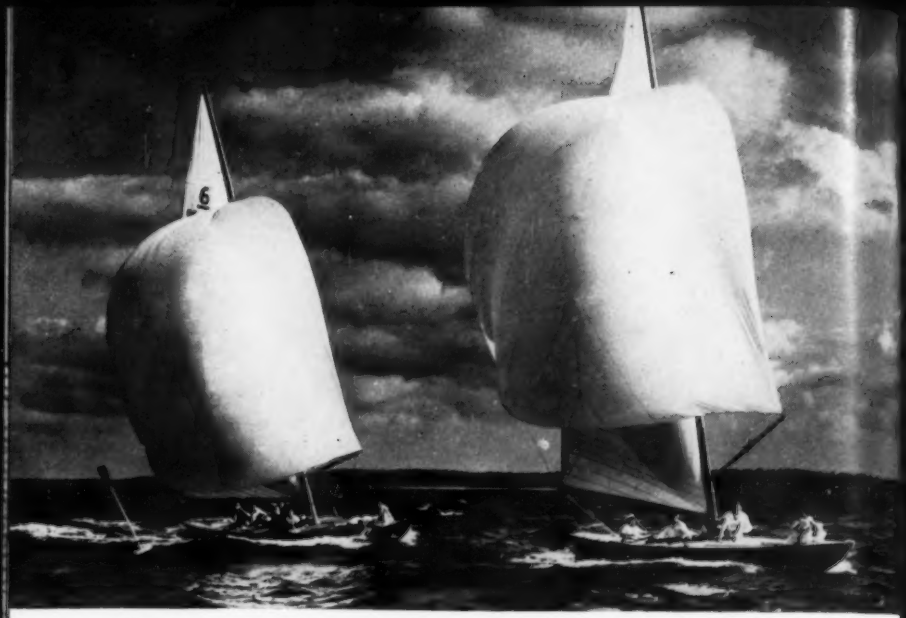
The July, 1956, issue of *Sea Frontiers* carried an article "Floating Fish Factories," by Robert W. Ellis, describing an experimental venture into fish factory ships by the Charles Salvesen Company of Leith, Scotland. The ship, *Fairtry,* was aptly named. It has done so well, in fact, that the British firm is adding two similar vessels to its fleet. They will include the same compact features that have proved so successful in *Fairtry*—stern operating net gear, mechanical filleting machines, freezers with storage at 10°F., in the fish holds, and a fish meal plant. It is significant to note that Russia now operates a fleet of fish factory ships, modelled largely upon the plans of the *Fairtry* and her predecessor, a converted vessel.

Bass Big As Tuna

A specimen of what may be the world's largest species of sea bass has been added to the collections of the Smithsonian Institution. It is a 337½-pound fish 78½ inches long, the third of its kind caught near Eniwetok Atoll in the mid-Pacific, scene of several atomic-bomb tests.

The great sea bass is challenged for size only by some sharks and some members of the tuna family. The largest of the Eniwetok specimens weighed 414 pounds and was more than 81 inches long.

This particular fish — *Promicrops lanceolatus*—is well known to northern Australians who prize it highly for food, but this is the first record for the Marshall Islands. It ranges the Pacific from Hawaii southward, and west to the Red Sea. It is closely related to the giant sea bass of the Atlantic and the eastern Pacific known as the jewfish.



BETTER TRIM ON THE SPINNAKER, *or large balloon-like sail, accounts for the lead of the 6-meter boat to the right. This is one of the points brought out by Cornelius Shields in his article "How to Win a Race," a chapter in* The Experts' Book of Boating, *reviewed on this page. (Photo from Prentice-Hall, Inc.)*

Science of the Sea in BOOKS

For General Reading

THE EXPERTS' BOOK
OF BOATING

RUTH BRINDZE (ed.). Prentice-Hall, Inc. Englewood Cliffs, N. J. 1959. xi + 291 pages. $5.95.

This is a book by experts, not for experts. The experts in question are the best. Ruth Brindze has put together boating wisdom from twenty-two sources (she herself does two chapters, one on cooking and one on cabin arrangements)—Rhodes on design, Ratsey on sails, Calahan on anchoring, Shields on racing, Loomis on navigation. Even the casual reader of yachting literature will recognize these names.

Today's small boatman is served with a shelf of excellent and authoritative books, several of them by authors of chapters in the present book. Nevertheless, even the reader who combines considerable experience afloat with considerable experience in armchair boating will find Mrs. Brindze's book worth while.

Several chapters have particular merit. The one on design by Philip Rhodes (which appeared in *Yachting* in the winter of 1958) is a good introduction to the scientific principles used in naval architecture; Thomas D. Nicholson's chapter on stars and the one on celestial navigation by

Alfred Loomis are unusual treatments of technical subjects. On a more down-to-earth plane, Mrs. Brindze's own chapter on food and cooking is valuable (even though she admits to a preference for such modish ships stores as turtle soup, vichyssoise, breast of guinea hen, hearts of palm), and so is J. Kenneth Whitteker's treatment of electrical systems.

Nor is the power-boat man neglected: there are chapters on both inboard and outboard engines, and on handling power boats in big seas.

Each author is introduced with a brief biographical note. There are appendices on the N.A.Y.R.U. yacht and pilot rules, a good index, many excellent illustrations, and colorful end papers made up of the international code flags. The book is well designed, set in easy-to-read two-column format. Altogether, *The Experts' Book of Boating* makes a worthwhile addition to the small boatman's library S.W.H.

ANGLERS GUIDE TO THE SALT WATER GAME FISHES — ATLANTIC AND PACIFIC.

EDWARD C. MIGDALSKI. The Ronald Press Company, New York, 1958. 506 pages, numerous illustrations. $7.50.

The public thirst for popular books on fishes, like that for birds, apparently is unquenchable. This book attempts to answer the anglers' "innumerable questions about the habits of fish: what they eat, where they spawn, how deep they lie in the water, what they do in the winter, or how they can be told apart." How well the reader is satisfied will vary with his background and expectations. The book is written in a pleasing style and reads well, although at points the writer seems confused. There are numerous photographs of fishermen and their catches.

Three major sections, open-ocean fishes, coastal and inshore fishes and the forty identification charts occupy most of the pages. A discussion of the International Game Fish Association and a brief glossary complete the work. Inevitably, the book reflects the background of the author. New England shore fishes, so familiar to him, and oceanic fishes, are treated in some detail while those from South Florida and West Indies are briefly dismissed.

Readers should not regard the book as a source of scientific information. Biologists, in fact, will wince at definitions which place snails, mussels and oysters in the cephalopods and call octopods "tiny eight-armed mollusks." Since a glossary was deemed necessary, its definitions may be expected to be full and authoritative. They are not. They are brief to the point of inadequacy and inaccuracy. Some 152 fishes are illustrated by line drawings on the 40 identification charts. Pertinent points of identification are printed around the drawings or indicated by arrows. Although fishermen will find it difficult to distinguish a dog snapper from a schoolmaster by this means, and will find no black "splotch" at the pectoral base of the red snapper (the blackfin snapper apparently was intended), the drawings are generally good.

Accounts of various oceanic and coastal fishes vary considerably in content. Although the author points to the work by various committees toward the stabilization of common names, he does not always follow their recommendations and uses a discouraging number of new or rejected names. He is not aware of recent scientific literature. For example, Ginsburg's paper (1952) on the jacks, pompanos and their allies was missed with the result that old errors are perpetuated.

The accounts make interesting reading but do not stand the test of careful examination. Florida anglers will be surprised to learn that the numerous species of groupers that they

catch are not game fishes, this despite the author's definition of game fishes as "any fish, regardless of species, which rod and reel fishermen pursue specifically."

One questions, too, the lengthy attempt to pass off the barracuda as a potential danger. As with sharks, and poisonous snakes, there exists one school to damn their every move and another to shout their innocence. The wise man will respect the barracuda. It is amusing to note here the words of another writer, "These fishes . . . (i e. barracudas) . . . are a real danger to bathers and are responsible for most of the attacks commonly attributed to sharks."

In summary the *Anglers Guide* will make pleasant reading for those who know little about fish and fishing. Sportsmen who seek answers to specific questions, usually will not find them or may be misinformed for their trouble. While information was drawn from scientific sources, it is regrettable that the author did not request an oceanographer and several ichthyologists to proofread early drafts.

C. R. R.

Technical Reading

EBB AND FLOW

ALFRED DEFANT. The University of Michigan Press. 1958. 121 pp. 64 figs. $4.00.

This is a translation from the original German text published five years earlier. It provides an adequate description of tidal phenomena in general, including mention of such interesting phenomenon as the 25 foot tidal wave or bore which races up the Chinese river Fuchum, at times. The mathematical treatment of tidal origins and methods of prediction takes this out of the realm of a truly popular book, but it should nevertheless be of interest to the yachtsman and fisherma as well as the marine biologist.

F.G.W.S.

INTRODUCTION TO THE THEORY OF SOUND TRANSMISSION

C. B. OFFICER. McGraw-Hill Book Co., Inc., New York. 1958. 28 pages. $10.

This reviewer had the occasion, several months ago, to comment briefly in *Sea Frontiers* on the then recently published *Elastic Waves in Layered Media* (Ewing Jardetzky and Press, McGraw Hill Book Co. 1958). It was necessary to indicate that the mathematical techniques employed were such as to make the work somewhat inaccessible to the general reader, or even to some readers interested in the physical problems treated.

The present volume by Dr. Officer, one of the rising authorities in the field, forms the perfect introduction to the specialized investigation of elastic wave propagation. More important, however, it constitutes an extraordinarily lucid treatment of a great variety of acoustical topics not easily found elsewhere, especially the material on the derivation of acoustic wave equations, ray theory and normal mode analysis. Several other matters briefly but very well presented are: waves of finite amplitude, integration by the method of steepest descents, and the evaluation of branch line integrals occurring in wave propagation theory.

The outstanding pedagogic merit of this work will make it a *vade mecum* of students of acoustic wave theory. If its somewhat uncomfortably high price ($10) does not inhibit its sale, it will soon be found on many a bookshelf.

R. B.

About the Authors

C. E. N. FRANKCOM

Before his apopintment as Director-General of the Meteorological Office of the Air Ministry, Mr. Frankcom had considerable experience in maritime matters, both ashore and afloat. From 1920 to 1936 he served as deck officer in the British merchant fleet, the last two and one-half years as Master. Joining the Board of Trade as a surveyor and examiner of Masters and Mates in 1936, he was appointed Marine Superintendent of the Meteorological Office in 1939. During World War II he was commodore of North Sea convoys and also took part in operations in the Mediterranean. He was President of the Commission for Maritime Meteorology from 1947 to 1957. His hobbies include gardening, amateur theatrics, riding and golf.

EDWIN IVERSEN

As with many other fishery biologists, a love of the outdoors started Mr. Iversen on a career by way of Michigan State University and the University of Washington to his M.S. in Fisheries.

Later he joined the Fisheries Research Institute in Alaska. He then travelled south to carry out research on Pacific tunas at Honolulu. He denies that Alaska was too cold for him, but he left Honolulu only to resume his scientific career under the warm skies of Miami.

MURRAY A. NEWMAN

Interest in aquatic or marine biology induced Murray Newman to live in a number of places. From the University of Chicago, where he received his B.A. in 1949 he went to the University of Hawaii. The following year he attended the University of California where he obtained his M.A. As curator of the collection of fishes at UCLA he went on a number of expeditions to the Gulf of California.

In 1953 he was appointed curator of the Institute of Fisheries Museum at the University of British Columbia, collecting specimens along the Pacific coast from Canada to Mexico. Invited to assist in the planning of Canada's first public aquarium in Vancouver, he was appointed its curator in 1955. He is now completing his doctoral studies on the behavior of juvenile trout and salmon.

Progress

DURING THE FEW YEARS of its existence *Sea Frontiers* has reached a membership which has more than doubled every twelve months. Members are drawn from the United States, Canada, Central and South America, Great Britain, Australia, France, Germany, Italy, Turkey, Denmark, Sweden and Norway as well as a few from the Pacific Islands, the West Indies and Russia.

CONTINUED IMPROVEMENT will be possible with growth of active membership. It will be seen in better service, with more articles in the magazine of high interest and authenticity and, eventually, a monthly issue in full color.

IN ADDITION TO PUBLISHING *Sea Frontiers* and *Sea Secrets*, the Foundation provides active support for scientific research and education. The ocean is our last frontier and its exploration still under way.

MEMBERS are joined in these aims and they are urged to make progress possible by taking the small effort needed to enlist new members. Sample copies will be mailed to friends upon request.

INVITATION: Those who are not members, but whose interest and curiosity lie in the sea and the spirit of discovery, may participate by simply mailing the card in this issue.

THE EDITOR will be glad to consider for publication articles and illustrations covering explorations, discoveries or advances in our knowledge of the marine sciences or describing the activities of oceanographic laboratories or expeditions in any part of the world.

The International Oceanographic Foundation

"To encourage the extension of human knowledge by scientific study and exploration of the oceans in all their aspects, including the study of game fishes, food fishes, ocean currents, the geology, chemistry, and physics of the sea and the sea floor."

MEMBERSHIP

The Foundation was established by a group of saltwater anglers, yachtsmen, shipowners, marine scientists and others interested in the scientific exploration of our last frontier, the ocean. Its objectives are to provide support and encouragement for marine research exploration and discovery and to promote the collection and dissemination of scientific knowledge about the ocean.

Qualifications for membership are an interest in the oceans and a desire to extend and develop scientific research and exploration into them. Support given to research through personal activities or donations is recognized by the Foundation through the following classes of membership. Members are those who make annual contributions of $5, Fellows $25 annually; Associates $100 annually; Life Fellows are those who contribute $200 or more or who have otherwise helped to advance the purposes of the Foundation; Sponsors who contribute $1,000 or more; and Patrons who contribute $5,000 or more. Corporate Associates contribute $1,000 annually.

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PRINTED BY PARKER, CORAL GABLES, FLORIDA, U.S.A.